Best Available Science and Existing Conditions Report for Island County's Fish and Wildlife Habitat Conservation Areas

Prepared for:

Island County Planning and Community Development Department PO Box 5000
Coupeville, WA 98239

Photos by: Su-Lauine Yeo Brodsky, Todd Nappen, and Chas Redmond

The Watershed Company

Parametrix
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BEST AVAILABLE SCIENCE AND EXISTING CONDITIONS REPORT

FOR ISLAND COUNTY'S FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Prepared for:

Island County Planning and Community Development Department
PO Box 5000
Coupeville, WA 98239

Prepared by:

THE WATERSHED COMPANY
750 Sixth Street South
Kirkland . WA 98033
p 425.822.5242
f 425.827.8136
watershedco.com

and

Parametrix
411 108th Avenue NE, Suite 1800
Bellevue, WA 98004
425.458.6200

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Innovation is in our nature.

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BEST AVAILABLE SCIENCE AND EXISTING CONDITIONS REPORT

FOR ISLAND COUNTY'S FISH AND WILDLIFE HABITAT CONSERVATION AREAS

1 INTRODUCTION

The Washington State Growth Management Act (GMA) mandates that cities and counties adopt policies and regulations to protect the functions and values of "Fish and Wildlife Habitat Conservation Areas" (FWHCAs) based on best available science (BAS) per WAC 365-195.

Fish and Wildlife Habitat Conservation Areas are defined in WAC 365-190-030(6a), as:

> "areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness."

Per WAC 365-190-130(2), the following areas must be considered for classification and designation as FWHCAs:

- Areas important to endangered, threatened, and sensitive species;
- Habitats and species of local importance, as determined locally;
- Commercial and recreational shellfish areas;
- Kelp and eelgrass beds;
- Forage fish spawning areas;
- Naturally occurring ponds under twenty acres;
- Waters of the State as defined in RCW 90.48.020;
- Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; and

State natural area preserves, natural resource conservation areas, and State wildlife areas.

In addition to those areas identified in the above list, counties and cities must also give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries (WAC 365-190-080).

In addition to regulating the minimum FWHCAs required by the WAC, the existing Island County FWHCA regulations also address:

- Species and Habitats of Local Importance as designated by reference at Island County Code (ICC) 17.02.050.C.1.h;
- Flora species included in Island County's Protected Species List (referenced at Island County Code (ICC) 17.02.050.C.1.j);
- All areas designated by the DNR through the Washington Natural Heritage Program as high quality wetland ecosystems and high quality terrestrial ecosystems and shown on the Map prepared by Island County dated October 11, 1999.

Under the County's existing FWHCA's, the following criteria must be met for a species to qualify as a Species of Local Importance:

1. Local populations which are in danger of extirpation based on existing trends (since January 1, 1985),
2. The species is sensitive to habitat manipulation, and
3. The species or habitat has commercial, game, or other special value, such as locally rare species.

Areas may be designated as Habitats of Local Importance if they meet the following criteria:

1. Documented use or high probability of use of the habitat by a species whose long term persistence is dependent upon conservation of the habitat or the habitat is proposed to be restored with the consent of the affected property owner so that it will be suitable for use by the species; and
2. Either high quality native habitat or habitat that has an excellent potential to recover to a high quality condition and which is either of limited availability or highly vulnerable to alteration.

3. Specific habitat features to be protected (for example, nest sites, breeding areas, nurseries, etc.).

1.1 GMA Regulatory Update Process

The GMA requires updates of both Comprehensive Plans and development regulations on a periodic cycle, based on an evaluation of changing conditions over time. The Comprehensive Plan establishes the vision and goals of the community. Required elements of the Comprehensive Plan include land use, housing, capital facilities, utilities, rural, transportation, economic development, and parks and recreation (RCW 36.70A.070). Policies related to Fish and Wildlife Habitat Conservation Areas occur in the Land Use Element, as well as the Natural Lands Element of Island County's Comprehensive Plan. Island County is scheduled to update the Natural Lands Element of its Comprehensive Plan by June of 2016. The current Natural Lands Element of the County's Comprehensive Plan was adopted in 1998. The Natural Lands Element includes policies related to the protection and conservation of "agriculture and forest areas, open space corridors, property rights, wetland and groundwater protection, retention of rural character, and wildlife habitat protection" (Island County, 1998). The policies adopted in both the Land Use and the Natural Lands Element provide the basis for development regulations, including critical areas regulations such as the FWHCA ordinance.

In 2012 Island County was the subject of an appeal on the basis of failure to timely update their development regulations by December 21, 2005, including the Fish and Wildlife Habitat Conservation Areas Ordinance as required by RCW 36.70A.130(1)(a), (c), and 4(b) (GMHB Case No. 12-2-0016). The appellant was successful in demonstrating that Island County had failed to update its FWHCA in a timely manner as required by the GMA. The GMHB issued a compliance order to Island County, requiring that it meet its obligations for FWHCA updates in compliance with GMA by December 2013. That date has been extended by mutual agreement of the parties to July 24 of 2014.

1.2 Purpose and Overview of This Report

The purpose of this report is to provide an update and analysis of existing conditions of habitats and species as they occur in Island County as the basis for considering regulatory updates to Island County's FWHCA ordinance. This document includes the Best Available Science for Island County. This report also establishes the basis for the technical literature as it relates to habitats and species, and specifically discusses the conditions of habitats and species as they occur in Island County. In addition this document discusses impacts to habitats and species, as well as protection needs of habitats and species. Recommendations for protection are also included.

In addition, this report is intended to serve as a landscape-based framework for understanding and conserving critical habitat and habitat-forming processes, as well as providing an information base for local-scale management considerations within Island County. Throughout this report, we identify the different scales of influence affecting habitats and species. Resource managers have suggested that a landscape-scale understanding is important to effectively manage land use to protect the functions and processes and habitat connectivity that are critical to the conservation of fish and wildlife species and their habitats (Dale et al. 2000, Cereghino 2010, Stanley et al. 2012). Therefore, Section 2 of this report begins with an analysis of landscape scale considerations that informed this project. Section 3 is focused on Island County and the habitats and species that occur within the county. Section 4 discusses Landscape Processes and the Effects of Development, while Sections 5 6, and 7 discuss freshwater, marine, and terrestrial habitats. Section 8 identifies data gaps, while Section 9 concludes with Management Implications.

1.3 Relationship to Shoreline Master Programs (RCW/WAC)

In 2010, House Bill 1653 clarified the integration of the Growth Management Act and the Shoreline Management Act. The Bill states that once the Washington State Department of Ecology (Ecology) approves an updated Shoreline Master Program (SMP) for a County or City, critical areas that fall within that County or City's shoreline jurisdiction will be managed through the updated SMP. The updated Island County SMP has been locally adopted, and it is presently under review by Ecology. Because approval of the SMP is expected to occur prior to the adoption of any new FWHCA management policies or regulations, the updated FWHCA regulations will not apply to land uses and modifications within shoreline jurisdiction, which is defined in the proposed SMP as: "all shorelines and shorelines of statewide significance, plus lands extending landward for 200 feet in all directions, as measured on a horizontal plane from the Ordinary High Water Mark of shorelines; associated floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams, lakes, and tidal waters subject to the SMA." Shoreline areas and activities regulated within shoreline jurisdiction, as covered by the proposed SMP updates, will not also be covered in this document, except where existing designated Habitats of Local Importance occur within shoreline jurisdiction. Those areas will be described in further detail in this report. However, the FWHCA regulations will apply to land uses outside of shoreline jurisdiction that may affect FWHCAs within shoreline jurisdiction. For that reason, this report focuses on summarizing the data relevant to management of land uses that fall outside of proposed shoreline jurisdiction, including the potential indirect effect of those land uses on marine and estuarine habitats.

Another area of potential regulatory overlap occurs with wetlands, which are regulated by ICC 17.02A. Island County's wetland regulations provide an approach to classifying wetlands and applying buffers, based on Best Available Science for wetlands (Adamus 2007). The County is planning to begin updating its Comprehensive Plan, including sections addressing wetland critical areas, beginning in 2014. Therefore, wetlands and wetland-obligate species will not be covered in depth in this document.

2 WATERSHED CHARACTERIZATION MODEL

As part of its regulatory update, and in compliance with the Growth Management Act requirement to use the Best Available Science, Island County chose to consider landscape-scale ecological processes as the first step in understanding existing conditions with respect to Fish and Wildlife Habitat Conservation Areas (WAC 365-190-130). Island County's intent was to consider these ecological processes as expressed in a set of assessments known as the Puget Sound Watershed Characterization jointly developed by Ecology, and WDFW, with support from the USEPA.

The Puget Sound Watershed Characterization is a coarse-scale decision support tool that can be used to inform watershed-based planning at the regional and local government level. The model, spatially organized around watersheds that are tributary to the Puget Sound, is comprised of several assessments, grouped by water flow, water quality, (collectively known as the water resources, and discussed in Volume 1 [Stanley et al. 2012]), and terrestrial, freshwater and marine habitats (collectively known as the habitat assessments, and discussed in Volume 2 [Wilhere et al. 2013). Each assessment of the watershed characterization aggregates relevant data sets available in GIS format, and compares the relative value of various portions of the landscape for their importance to the ecological process under consideration for providing water flow, water quality, and habitat function. The characterization further identifies areas on the landscape that are most suitable for restoration, conservation, protection, or those areas which may be best suited for additional development because they lack intact water or habitat resources.[1]

The intent of watershed characterization is to analyze ecological conditions from a landscape scale perspective. By understanding the relative condition of ecological processes on a landscape, local governments can ensure the restoration and protection actions are targeted where they will have the most value.

In the context of Fish and Wildlife Habitat Conservation Areas ordinance, the results of Watershed Characterization's assessment was thought to provide insight into the ecological processes that affect habitats and species of local importance; ecological process leads to structure, which provides habitat function. In a river, for example, the processes of water and sediment movement produce sediment bars and channel features (structure), which in turn provide off-channel rearing habitat for salmonids (function). To maintain or restore the structure and function of the Puget Sound ecosystem, important watershed processes that are still intact need to be identified and protected, and those that have been severely degraded need to be restored.

By understanding the relative importance and condition of ecological processes, based on consideration of Puget Sound Watershed Characterization results, Island County would be in the position to look beyond individual species, to ensure that the underlying ecological process that sustained the habitat and species would be identified and considered for protection as part of the regulatory update process. The intent of the model is to engage in a holistic analysis of the ecosystem to ensure that habitats and species are sustainable in the long-term, thus complying with the Growth Management Act's rule related to regulatory updates (WAC 365-190-130), as well a Growth Management Hearing's Board (GMHB) compliance

[1] The model ties these terms ('restoration', 'protection', 'conservation', 'development'), to model output results. See Volume 1 discussion of Watershed Management Matrix for more information on model output and how to interpret model results.

order which requires the County to adopt an updated Fish and Wildlife Habitat Conservation Areas Ordinance by July 2014.

2.1 Watershed Characterization Volume 1 - Water Flow

Island County convened a technical advisory group (TAG), composed of local experts regarding habitat conditions on Island County, as an advisory group to its regulatory update process. Two meetings were held with the TAG to explain how Watershed Characterization works, and how to interpret model results. Forty-eight maps were prepared for analysis, showing importance and degradation for all subcomponents of Water Flow, (Volume 1, Watershed Characterization) as well as the Habitat Assessment Models (Volume 2).

The Watershed Characterization Water Flow model breaks the landscape into three landscape groups, Mountainous, Lowland, and Coastal Units. The Mountainous landscape group does not occur within Island County.

At an initial meeting with the Island County Technical Advisory Group (TAG), a recommendation was made to combine Lowland and Coastal Landscape groups into one landscape group. The model compares Assessment Units within Landscape group, so this decision had the effect of creating one landscape group within Island County such that all model results are compared within that landscape group.

Department of Ecology staff, who attended and participated in the TAG meeting, made this change to the model, and further recommended that the County focus its analysis primarily on the storage and discharge submodels of water flow, since these submodels are related to the presence and condition of depressional and slope wetlands, which are known to be essential for maintaining stream flows, and in turn, fish habitats.

Both the surface storage and discharge submodels use the presence of depressional wetlands for scoring, but can also be used to indicate where the most important upland areas for conserving aquatic habitats may be located in Island County.

For scoring the level of degradation to wetlands, the storage submodel evaluates the intensity of development adjacent and upland of wetlands. The discharge submodel also looks at road density (roads intercept shallow groundwater flow) within the contributing watershed of a wetland. Both of these degradation factors for water flow also impact the movement of wildlife in and out of wetlands. Therefore the results of the storage and discharge submodels could be used to evaluate the general effect of watershed development on the habitat function of wetlands, which, in turn, may be correlated to higher productivity and species richness.

By starting with the AUs scored for "protection" Island County could add results from both the terrestrial habitats characterization model and additional finer scale information in order to support final decisions on qualifying Fish and Wildlife Habitat Conservation areas. While this analysis was considered for use in the FWHCA ordinance update, it was determined, in consultation with Island County and Department of Ecology staff, that wetlands are a critical area already protected under Island County's ordinance, and that identifying specific, high quality wetlands as correlated to higher species productivity would be too indirect an approach for this regulatory update process. After discussion, it was decided not to pursue further analysis of the Water Flow submodels for discharge and storage with respect to FWHCA regulatory updates, though it was noted that this information should be considered for policy updates as a part of the Comprehensive Plan update process scheduled for 2016.

With respect to Water Quality, it was determined the Island County Water Quality database, and the data on recharge provided by Doug Kelly, (Island County staff hydrogeologist), provided a finer scale of resolution than that provided by either the recharge subcomponent model or the water quality model of Watershed Characterization. Therefore, Ecology recommended using Island County's local data sets as most appropriate for analysis instead of the Watershed Characterization subcomponent models for water quality and recharge. It should be noted that recharge is a process critical to aquifers that is beyond the scope of this regulatory update. Aquifer recharge analysis should form the basis of the critical areas ordinance related to that subject area, and is beyond the scope of this Fish and Wildlife Habitat Conservation Areas ordinance update. Water quality monitoring results from Island County are discussed in Section 4.2 of this report.

2.2 Watershed Characterization Volume 2 – The Habitat Assessment Models

Volume 2 of the Watershed Characterization includes habitat assessment models for terrestrial habitat, freshwater habitat, and marine shoreline habitat. Results from the terrestrial habitat assessment model were presented at a TAG meeting in October of 2013. Based on the map results, the TAG had concerns regarding the accuracy of some of the model outputs. WDFW staff analyzed the results and determined that one of the underlying data sets, the Washington State Parcel Database (RTI 2011) used land use codes which may have been inaccurate. For example, the database identified parcels within Deception Pass State Park as residential, while in fact these forested parcels are not under threat of development.

An effort was made to determine how to resolve this problem. Unfortunately, each tax parcel in the database would have to be analyzed for accuracy, which would involve analyzing thousands of parcels. This would be a significant increase in the level of effort anticipated as part of the project, and could not be undertaken given the project schedule mandated by the GMHB Compliance Order.

Because Island County was interested in understanding the relative value of its habitats, and use of those habitats by species, as determined by a model, WDFW staff spent considerable time and effort working with Island County and the project team to develop alternative approaches to using the Watershed Characterization Volume 2 models, or failing that, alternative maps above and beyond existing data sets, that could provide Island County with a path forward. WDFW provided three map sets for analysis. The first is a map set that shows anadromous fish use on one map, and shows all streams (both those supporting anadromous fish, and those for which no data on anadromous fish are present) in Island County. This map is analyzed in greater detail in Section 3.2 section of this report. The second is a map set that shows terrestrial habitats and open space within Island County. This map is analyzed below. The third map set shows the marine shoreline habitat assessment model results, and is paired with a graphic that highlights both habitats of local importance, as designated by Island County's FWHCA ordinance, as well as some significant habitats (per WDFW's Priority Habitats and Species (PHS) data) that are not specifically protected by ordinance in Island County. These map sets are discussed in section 3.7 of this report.

3 Island County Setting

Island County is located in north central Puget Sound in the Salish Sea, surrounded by the Strait of San Juan de Fuca to the west, and Georgia Strait to the north (Map 1). Island County comprises two long, linear islands, Whidbey Island to the west, and Camano Island to the east. Saratoga Passage is the body of water between the two islands. Seven smaller islands are also included within Island County. Whidbey Island is approximately 35 miles long and varies in width from 1.2 to 12 miles wide, and approximately 170 square miles in size. Camano Island is somewhat smaller, at approximately 100 square miles in size. Camano Island is separated from Snohomish County to the east by Possession Sound and Port Susan. Island County contains 196 miles of marine shoreline and 11 miles of lake shoreline (ESA 2012). Two major river systems, the Skagit River and the Snohomish River are located just to the east of Island County. The Olympic Mountain range is located to the west. Annual precipitation in the County ranges from approximately 18 inches in central Whidbey Island to 60 inches in portions of southern Whidbey Island. Most precipitation falls as rain in the period from October through March. The County does not typically receive significant snowfall, and the rare rain-on-snow events are not a significant factor in the hydrology of the County's watersheds. The soils on the glacial uplands and terraces exhibit moderately good drainage, and soils in upland depressions and deltas exhibit poor natural drainage (USDA 1958).

The County does not have any rivers, and most streams are intermittent or ephemeral. Dikes and tidegates have created upland and freshwater habitats in areas that were historically estuarine habitats, including portions of some of the larger watersheds in the County, such as the Maxwelton and Dugualla basins. Although much of the historic prairie and oak woodlands have been lost to agriculture and development, small areas of prairie still remain in central Whidbey Island.

The following data sources are useful identifying and understanding the flora and fauna of Island County:

Native Plant Society Plant List for Whidbey Island
http://www.wnps.org/plant_lists/counties/island/island_county.html

Prairie and Oak Woodland Habitats and Associated Rare Species on Whidbey Island (Sheehan 2007)

Whidbey Audubon Society- Bird Check List
http://www.whidbeyaudubon.org/birdlist/

*Willamette Valley- Puget Trough- Georgia Basin Ecoregional Assessment (*Floberg et al. 2004)

The majority of the County is in residential use, although government-owned lands, timber, and agriculture also constitute significant land use areas in the County. With respect to timber harvest, in a comparative study of timber harvest conversion rates between 2005 and 2008 in WRIAs 5 (Stillaguamish) 6 (Island County), and 7 (Snohomish Basin), WRIA 6 showed that while harvest acreage rates generally corresponded with WRIA size (with size order being WRIA 7 having the largest upland harvestable area, then WRIA 6, then WRIA 5) the timber conversion rates documented that WRIA 6 had a conversion rate density nearly three times higher than WRIA 5 and nearly two times higher than WRIA 7. (Shattuck and Marks. 2009). Over 90 percent of the county is zoned for low density residential development (SRP 2005). Island County's population is projected to increase from just over 80,000 in 2010 to approximately 93,000 in 2040, per intermediate population projections (OFM, 2012). The County is one of the smallest counties in the state by area, yet has one of the highest densities per area, at 300 people per square mile (Island County Comp Plan. 2011). Population growth has gradually slowed in recent years within the County, and the Island County Planning Department projects an average 0.46 percent annual growth rate through the year 2036 (Island County 2013). Most of Island County is zoned rural, and rural zoned areas have a minimum allowable lot size of one dwelling unit per 5 acres. Continued population growth will likely result in a greater proportion of permanent residences and residential development through subdivision of large lots to the minimum allowable lot size (one dwelling unit per 5 acres in rural-zoned areas, which compose the greatest area in the County).

Land conversion from agriculture and forestry to more intensive land uses and higher densities has occurred in the County (SRP 2005, and as noted above), and it is expected to continue. In contrast to residential development growth in the County, areas devoted to agricultural production have decreased in the County in recent years. Between 2002 and 2007, there was an 18 percent reduction in area of land in agriculture in Island County (USDA 2007). Between 2005 and 2012 the average annual acreage converted from forestry to non-forestry uses was 28.15 acres for Camano Island and 100.51 for Whidbey Island (Shattuck and Marks 2009).

Island County code does not currently identify fish and wildlife habitat corridors, although the Growth Management Act does state that counties and cities should consider "*Creating a system of fish and wildlife habitat with connections between larger habitat blocks and open spaces, integrating with open space corridor planning where appropriate*" (WAC 365-190-130(3)(a)(i).

Adequate corridors and habitat connectivity are required to support sustainable habitats for species dispersal, breeding, and foraging, and to sustain viable populations over the long term. Habitat corridors and connectivity needs vary considerably based on species requirements. Therefore the establishment of habitat corrid12ors should be premised on a consideration of specific desired habitats and species of concern.

WDFW has provided a set of maps that show the percentage of terrestrial habitats and open space currently present in the County by the percentage of forest and shrub cover per parcel.

The panels in Figure 1 show tree and shrub cover based on the percentage of cover on individual parcels on Island County using parcel data and land cover data developed by WDFW as the basis for analysis. The dark green indicates areas of high forest/shrub cover, while the yellow to red indicates areas of low forest/shrub cover. These maps show the areas within Island County that contain increasingly higher percentages of forest/shrub cover. Forest and shrub cover are indicators of habitat connectivity, and are important structural elements for many terrestrial species which are wholly or partially dependent on cover for at least portions of their life cycle.

Because the County consists of two islands, dispersal of some species (e.g., plants, amphibians, reptiles, and small mammals) to areas outside the County may be limited or non-existent. The smaller population sizes and dispersal ranges of island organisms, and potential unique characteristics resulting from evolutionary isolation, make them sensitive to anthropogenic change (Caujape-Castells et al. 2010). Because species are not likely to recolonize from other areas, population declines within the County may potentially be a

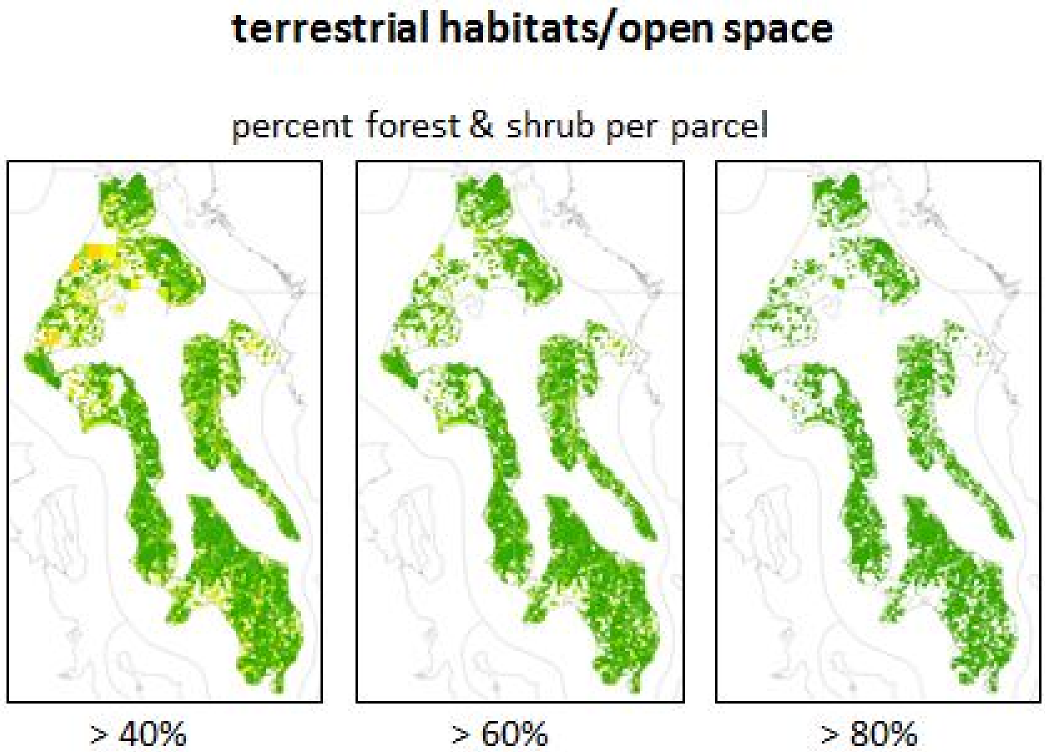

Figure 1. Terrestrial Habitat – Cover. Dark green indicates areas of high forest/shrub cover, while the yellow to red indicates areas of low forest/shrub cover.

greater concern in Island County than similar declines in mainland areas. Rare species may be particularly vulnerable to extinction resulting from stochastic events, and low genetic variability may limit population resilience (Caujape-Castells et al. 2010).

For Island County, important policy considerations should include the establishment of habitat corridors to protect areas that might become geographically isolated due to encroaching development. Such areas occur west of Oak Harbor (due to urbanization), in the Greenbank area (north of Freeland, due to the narrowness of the Island at this location), and south of Freeland due to development. These areas are identified and discussed in the Island County Comprehensive Plan, Parks and Recreation Element, which also proposes potential habitat corridors based on Island County conservation considerations as presented in the Plan (Island County Comprehensive Plan, 2011). It should be noted that the Parks Element is broader than wildlife habitat conservation corridors. Open space and wildlife habitat corridor protection policies will be updated by 2016. The work done as a part of the Parks Element with respect to conservation priorities and corridors should be considered as a part of this update.

The map provided by WDFW with respect to terrestrial habitat and open space cover by parcel, confirms the geographic areas of highest vulnerability west and north of Oak Harbor, in the Greenbank area, and south of Freeland. Habitat corridors should be considered in areas of highest vulnerability as a part of Comprehensive Plan policy updates during the 2016 Comprehensive Planning process for Island County. Because no existing habitat corridors are designated or protected by the current ordinance, this issue is not further discussed in this report.

3.1 Fish and Wildlife Habitat Conservation Areas in Island County

3.2 Endangered, Threatened, or Sensitive Species and Species of Local Importance

Species occurring in Island County that are State or federally listed as endangered, threatened, or sensitive or are identified as Species of Local Importance or Protected Species in Island County (ICC 17.02.050.C.h and i) are identified in Table 1. Those species specifically called out by Island County Code are shown in bold in Table 1. Map 2 identifies documented locations of locally protected flora and fauna, as well as species of local importance. The Washington State Department of Fish and Wildlife (WDFW) and the Washington State Department of Natural Resources (WDNR) (Natural Heritage Program) identify priority species, habitat types, and ecosystems in each county. In Island County, all WNHP high quality wetland ecosystems and high quality terrestrial ecosystems are considered habitats of local importance (ICC 17.02.050.C.1.j[2]). The locations of these communities are shown on Map 3. However, not all species and areas recognized or recommended by either department must be singled out and designated by counties and cities for extraordinary protection or management (WAC 365-190-040 4b). Many of the State, federal, and locally designated species function as indicator species because of their association with a specific environmental condition. The condition of these species can help to identify

[2] The code specifically refers to a map prepared by Island County dated October 11, 1999. That map is reproduced here as map xx.

changes in habitat functions and processes needing protection. Those species that are not protected by Island County's current code are shown on Map 4.

Table 1. Federal and State Listed Endangered, Threatened, and Sensitive species

Common Name	Scientific Name	State Status	Federal Status	Current Island County Designation	Habitat in Island County[1]
Anadromous Fish					
Coastal-Puget Sound Bull Trout	*Salvelinus confluentus*	Candidate	Threatened		Nearshore
Hood Canal Summer Chum Salmon	*Oncorhynchus keta*	Candidate	Threatened		Nearshore, potentially pocket estuaries and lower reaches of streams
Puget Sound Chinook Salmon	*O. tshawytscha*	Candidate	Threatened		Nearshore, pocket estuaries, and lower portions of streams
Puget Sound Steelhead	*O. mykiss*	Candidate	Threatened		Streams
Marine Species					
Steller (Northern) Sea Lion	***Eumetopias jubatus***	**Threatened**		**Protected**	**Nearshore/offshore**
Gray Whale	***Eschrichtius robustus***	**Sensitive**		**Protected**	**Nearshore/offshore**
Humpback Whale	*Megaptera novaeangliae*	Endangered	Endangered		Offshore
Puget Sound/Georgia Basin Boccaccio	*Sebastes paucispinis*	Candidate	Endangered		Kelp forests, eelgrass beds, nearshore/offshore
Puget Sound/Georgia Basin Yelloweye Rockfish	*Sebastes ruberrimus*	Candidate	Threatened		Kelp forests, eelgrass beds, nearshore/offshore
Puget Sound/Georgia Basin Canary Rockfish	*Sebastes pinniger*	Candidate	Threatened		Kelp forests, eelgrass beds, nearshore/offshore
Southern Resident Killer Whale	*Orcinus orca*	Endangered	Endangered		Offshore
Birds					
American white pelican	*Pelecanus erythrorhyncos*	Endangered	None		Offshore, estuaries (CL, PC)

Common Name	Scientific Name	State Status	Federal Status	Current Island County Designation	Habitat in Island County[1]
Bald eagle	***Haliaeetus leucocephalus***	**Sensitive**	**Species of Concern**	**Protected Species**	**Ponds and lakes, wetlands, estuaries(CL, PC, CH, DH), and forest**
Brown pelican	*Pelecanus occidentalis*	Endangered	Species of Concern		Offshore, estuaries (CL)
Common Loon	***Gavia immer***	**Sensitive**	**None**	**Species of Local Importance (nests are protected habitats)**	**Offshore and estuaries (PC, CH, CL, DH)**
Great Blue Heron	***Ardea herodias***	**None**	**None**	**Species of Local Importance (nests are protected habitats)**	**Wetlands, riparian areas, and estuaries (PC, CH, CL, DH)**
Marbled Murrelet	***Brachyramphus marmoratus***	**Threatened**	**Threatened**		**Offshore and estuaries (PC, CL), potential nest sites in old-growth forests**
Northern Spotted Owl	*Strix occidentalis caurina*	Endangered	Threatened		Forest
Osprey	***Pandion haliaetus***	**None**	**None**	**Species of Local Importance (nests are protected habitats)**	**Ponds and lakes, snags and platforms, and estuaries (CL, DH)**
Peregrine falcon	***Falco peregrinus***	**Sensitive**	**Species of Concern**	**Protected Species**	**Open areas (water and terrestrial), estuaries (PC, CL, DH), cliffs**
Pileated Woodpecker	***Dryocupus pileatus***	**Candidate**	**None**	**Species of Local Importance (nests are protected habitats)**	**Forests with large snags, developing areas, estuaries (PC, CL)**
Short-tailed Albatross[4]	*Phoebastria albatrus*	Candidate	Endangered		Offshore
Trumpeter Swan	***Cygnus buccinator***	**None**	**None**	**Species of Local Importance**	**Ponds and lakes, estuaries (CL, DH), fields**

Common Name	Scientific Name	State Status	Federal Status	Current Island County Designation	Habitat in Island County[1]
Reptiles					
Western Pond Turtle[4]	*Actinemys marmorata*	Endangered	Species of Concern		Streams and riparian areas
Invertebrates					
Taylor's Checkerspot	*Euphydryas editha taylori*	Endangered	Endangered		Prairies and oak woodlands
Plants[2]					
Golden Paintbrush	***Castilleja levisecta***	**Endangered**	**Threatened**	**Protected Species**	**Prairies**
White Meconella	***Meconella oregana***	**Threatened**	**Species of Concern**	**Protected Species**	**Herbaceous balds**
White-top Aster	***Sericocarpus rigidus***	**Sensitive**	**Species of Concern**	**Protected Species**	**Prairies**
Bulb-bearing Water-Hemlock[3]	***Circuta bulbifera***	**Sensitive**	**None**	**Protected Species**	**Wetland-obligate**
Black Lily3	***Fritillaria camschatcensis***	**Sensitive**	**None**	**Protected Species**	**Near lakes, streams, wetlands (1 documented occurrence on Camano Island)**
Tall agoseris3	***Agoseris elata***	**Sensitive**		**Protected Species**	**Prairies, ridges, and open woods**
Alaska alkaligrass	***Puccinellia nutkaensis***			**Protected Species**	**Salt marshes, gravel ridges, mud flats, moist pockets of prairies**

1 Information on documented occurrences in Island County are included where available. Note that habitat protection is not limited to those habitats identified. CL: Crockett Lake, PC: Penn Cove, CH: Crescent Harbor Marshes, DL: Deer Lagoon (ebird), although other habitats are also likely to be occupied.
2 Plants identified in the County's Protected Species List in existing FWHCA regulations (ICC 17.02).
3 Most recent sighting in the county is before 1977.
4 Although these species are identified in the WDFW PHS data for Island County, they are either locally extinct or not expected to occur in the County (R. Milner, WDFW, personal communication, December 16, 2013).

Threatened, endangered, and sensitive species, as well as Species of Local Importance, organized by habitat, are briefly described below:

Aquatic Species

Bull trout- Bull trout do not spawn or rear in freshwater habitats in Island County; however, bull trout have been found in the County's nearshore habitats. A recent study of bull trout movement in Skagit Bay, found that approximately two thirds of the bull trout tagged in Skagit Bay remained in the Bay, and seemed to exhibit some level of site fidelity within the Bay (Hayes et al. 2012). Many of the tagged fish occurred on the eastern shorelines of Whidbey Island and the northern shorelines of Camano Island (Hayes et al. 2012). The study further found that bull trout typically occurred within 0.4 km from the shore in waters less than 4 meters. Use of spit-berm, green algae, and eelgrass habitats was higher than would be anticipated based on their occurrence, suggesting that bull trout preferentially use these habitats (Hayes et al. 2012). Forage fish and juvenile salmonids are important prey species for bull trout in marine waters (SRP 2005).

Hood Canal summer chum salmon- Juvenile chum salmon occur along the County's shorelines in shallow, nearshore habitats and pocket estuaries (Beamer et al. 2006a). The distribution of listed summer chum and unlisted fall chum salmon occurring along the Island County shorelines has not been established; however, regional fisheries scientists suggest that the majority of chum salmon occurring in the Whidbey Basin are fall chum (SRP 2005).

Chinook salmon- Island County does not support independent Chinook salmon populations; however, Chinook salmon fry have been documented to rear in many small streams and pocket estuaries in the Whidbey Basin areas of Island County (Beamer 2006, Beamer et al. 2013). In particular, Juvenile Chinook have been documented using the lower reaches of small, freshwater streams that are accessible to the nearshore, including those that are temporally and/or spatially intermittent (Beamer et al. 2013). It is likely that the streams provide a physiological refuge for juvenile Chinook salmon in their adaptation to saltwater, as well as foraging opportunities (Beamer et al. 2013). Growth rates of individual juvenile Chinook salmon in small streams were similar to the growth rates of juvenile Chinook salmon in noted productive rearing habitats such as pocket estuaries and tidal delta scrub shrub habitat (Beamer et al. 2013)., These results indicate that independent small coastal streams have the ability to provide fry migrant Chinook salmon with suitable rearing habitat and should be considered important for juvenile Chinook salmon (Beamer et al. 2013).

Additionally, the County is located in an important geographic position along the marine migration corridor for all 22 independent populations of the Puget Sound Ecologically Significant Unit (ESU). In particular, Chinook salmon from the Skagit, Snohomish, and Stillaguamish rivers, have been documented to use the nearshore habitats of the Whidbey Basin (SRP 2005). In particular, juvenile Chinook salmon have been found to occur in pocket estuaries throughout Whidbey and Camano Islands, and these habitats likely provide important foraging and rearing areas for the species (Beamer et al. 2003, Beamer et al. 2006a, discussed further in Section 4.3.3).

Steelhead- Steelhead typically spend 1-3 years in freshwater, before emigrating to marine waters. Steelhead have been documented in Strawberry Point Creek, Kristoferson Creek, & Zook Creek (officially unnamed creek south of the Clinton ferry terminal, sometimes referred to locally as 'Old Clinton Creek'[3] (Beamer et al. 2013). The steelhead identified in the small streams of Whidbey Island were assumed to be more than one year old based on their size. However, they were not as large as the general size range of outmigrating steelhead smolts and were most likely not ready to migrate to sea (Beamer et al. 2013).

Other salmonids- In addition to the federally threatened salmonids, addressed above, the WAC requires that jurisdictions give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries (WAC 365-190-080). Other anadromous salmonids occurring in the County include pink (*Oncorhynchus gorbuscha)*, coho (*O. kisutch*), and sockeye (*O. nerka*) salmon and cutthroat trout (*O. clarkii*) (SRP 2005). Of these, coho salmon is a federal species of concern.

Whereas pink salmon emigrate from their natal freshwaters to enter marine waters days to weeks after emergence, coho salmon, sockeye salmon, and cutthroat trout typically reside in freshwater habitats for one year or more prior to emigrating to marine waters. Similar to other salmonid species that emigrate to marine waters shortly after emergence (e.g. Chinook and chum salmon), pink salmon are commonly found in pocket estuaries in Island County (Beamer et al. 2006a).

Within Island County, coho salmon spawn in Maxwelton Creek, where the coho population has been supplemented by outplanting of fry beginning in 1956. Coho

[3] The reference to Old Clinton Creek was provided by Steve Erickson, personal communication, 1/24/14.

and chum salmon have also been documented in upstream areas in Glendale Creek, Kristoferson Creek, and Chapman Creek (SRP 2005). Redds and coho fry have been documented in Zook Creek (Beamer et al. 2013). Coho salmon were documented in the lower reaches of 31 out of the 64 streams sampled in Island County (Beamer et al. 2013).

Cutthroat trout, which may exhibit either resident or anadromous life histories, are also present in several of the freshwater streams in Island County. Coastal cutthroat trout were identified in the lowermost reaches of 23 streams in Island County (Beamer et al. 2013). Factors affecting freshwater habitat characteristics for salmonids are discussed in detail below.

Boccacio, yelloweye, and canary rockfish- These rockfish are long-lived with generally similar life histories. Larval rockfish are dispersed by currents, and juveniles settle in shallow, nearshore habitats such as kelp and eelgrass beds or sandy areas (NMFS 2010). As rockfish species mature, they are associated with rocky habitats ranging from 10 to several 100 meters deep (NMFS 2010). As adults, bocaccio tend to be more pelagic than either yelloweye or canary rockfish. Observations of bocaccio, yelloweye and canary rockfish are rare, and the proportion of incidental catch of these species has decreased significantly over the past three decades (NMFS 2010). Indirect effects from upland development may include water quality impacts, effects on invertebrate or fish prey, and effects on shallow water habitats for juveniles.

Steller Sea Lion- The Eastern Distinct Population Segment (DPS) of Steller sea lions occurs in marine waters on the Washington Coast and Puget Sound. The population abundance and productivity of the Eastern DPS has increased substantially over the last 30 year (NMFS 2013). Following a petition by the States of Washington, Oregon, and Alaska, the National Marine Fisheries Service (NMFS) delisted Steller sea lions in October 2013 (NMFS 2013). However, Steller sea lions are presently still listed as threatened in Washington State. Steller sea lions are not included in WDFW's PHS list as occurring in Island County. However, they are listed as a protected species by Island County's FWHCA ordinance, and have been observed in the vicinity of Fort Casey State Park (Sarah Schmidt, personal communication, January 27, 2014[4]). In addition, Elephant seals have been documented over the past two to three years molting on the

[4] Marine mammal haul out locations can be confirmed at: http://www.orcanetwork.org/strandings.html

beach north of Double Bluff, remaining on the beach for two to three days at a time (Sarah Schmidt, personal communication, January 27, 2014). Indirect effects of upland development on Steller sea lions may include impacts to water quality and food sources.

Gray whale- Gray whales occasionally occur in marine waters near Island County during their annual migration between feeding grounds in Alaska and breeding grounds in Mexico. Northbound whales pass through Washington waters from March through May. Some enter Puget Sound, and a few summer there (WDFW 1997). Gray whales feed on benthic invertebrates by filtering sediments from the sea floor. Based on photo identification of individuals, several gray whales return most years to waters around Island County, feeding on benthic invertebrates (including ghost shrimp) for several months (Orca network, electronic reference). Gray whales are listed as a protected species in Island County's FWHCA ordinance. Feeding grounds for Gray whales are mapped by WDFW as occurring off the east and northwestern portions of Camano Island (Map 2). Indirect effects of upland development on gray whales may include impacts to water quality and food sources.

Humpback whales- Humpback whales are rare in Puget Sound, although sighting frequency has increased in the last decade (Falcone et al. 2005), along with a general increasing trend in population levels in the eastern Pacific (NMFS 2005). Humpbacks filter plankton and forage fish, particularly herring, through their baleen. They exhibit site fidelity to feeding areas accessed as juveniles (Falcone et al. 2005). As with the other whales, impacts to water quality and habitats that support prey production may reduce foraging opportunities for humpback whales.

Southern resident killer whale- The Southern Resident population consists of three pods, labeled J, K, and L, with a total of 81 individuals in 2013 (Orca Network, electronic resource). Southern resident killer whales spend a portion of the year, typically spring, summer, and fall, in inland marine waters in Washington State (NMFS 2008). Within Puget Sound, killer whale occurrences are concentrated on the south side of the San Juan Islands, although they do occur along the more open waters of Island County (NMFS 2008). Southern resident killer whales feed primarily on fish, with a strong preference for Chinook salmon, which composed 78 percent of identified prey from late spring to fall (Ford and Ellis 2006). Other prey species include chum, coho, steelhead, sockeye, and non-salmonids (such as Pacific herring and quillback rockfish). Recent research suggests that prey limitation is a significant physiological condition affecting southern resident whales (Ayers et al. 2012). Development activities that impact water quality, prey populations or habitats such as eelgrass, kelp, and forage fish spawning beaches may indirectly threaten southern resident killer whales (NMFS 2008).

Birds

American white pelican- White pelicans are uncommon, non-breeding winter visitors to shallow bays in Island County. White pelicans forage on small fish and invertebrates, and flocks may forage cooperatively by circling around fish or by driving fish towards the shore (Evans and Knopf 1993 in WDFW 2012). Breeding birds are highly sensitive to disturbance (Seattle Audubon Society 2005). The only breeding colony of white pelican was established in 1997 in Washington, and occurs in the McNary National Wildlife Refuge in Walla Walla County (WDFW 2012).

Bald eagle- The bald eagle population has recovered significantly since the ban on DDT use in 1972; by 2005, there were signs that the bald eagle population had reached carrying capacity in areas in western Washington State (Stinson et al. 2007). Bald eagles were federally delisted in 2007. In Washington State, bald eagles were reclassified from Threatened to Sensitive. Bald eagles and their nests are still protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. They also receive special protection under RCW 77.12.655; however, the State no longer requires bald eagle management plans for activities near bald eagle nests. If at any point the bald eagle is listed as an endangered or threatened species (federally or by Washington State), the state requirement to develop a management plan will be restored. Bald eagles are identified as a protected species under Island County's FWHCA, and the code references WAC 232-12-292 (Washington State Bald Eagle Protection Rules). Although these rules have been changed since Island County's FWHCA ordinance was created, and no longer require the preparation of bald eagle management plans, work in and around bald eagle nests and habitat still requires consultation with the USFWS to ensure compliance with the federal Bald and Golden Eagle protection act. The bald eagle is still listed by WDFW as a sensitive species, and its habitat and nesting territory may still be protected by local governments in compliance with the Growth Management Act. Bald eagle nests occurring in Island County are shown on Map 2. As of 2005 WDFW no longer has funding for Bald eagle surveys. The most recent surveys can be accessed at http://wdfw.wa.gov/conservation/bald_eagle/territory.

Bald eagles forage on dead or live fish, waterfowl, or small mammals (Stinson et al. 2007). In Washington, most bald eagle nests occur within 100 m (328 ft) of marine, lake, and river shorelines, and virtually all nests occur within one mile of shorelines (Stinson et al. 2007). Nesting sites range from old-growth forests to forests amid rural-residential development, but bald eagles require large trees to support their nests, and they typically select the largest tree in a stand for nesting (Stinson et al. 2007). In addition to water quality and prey populations, the long-term supply of tall trees is important to supporting bald eagle populations (Stinson et al. 2007).

Individual eagles have demonstrated habituation to continued exposure to human disturbance (Steidl and Anthony 2000). However, the species is usually found to be highly sensitive to human activities both in winter (Stalmaster and Kaiser 1997) and around nest sites, which could adversely impact foraging and reproductive success (Steidl and Anthony 2000). Breeding activity budgets were significantly different between birds exposed to human campsites 100 and 500 m (328 and 1640 feet) from nests. WDFW recommends avoiding disturbances at that time from loud machinery within approximately 244 m (800 feet) of known nest sites. Other activities that might be disruptive within about 122 m (400 feet) of communal roosts (regularly-used clusters of trees where eagles sleep) also should be avoided, especially where visually screening vegetation is sparse or absent (Watson and Rodrick 2000).

Brown pelican- Non-breeding brown pelicans occur rarely in Island County. Habitat use has been associated with the environmental parameters of water depth, distance to shore, and water temperature (Briggs et al. 1983). Non-breeding birds' diets are not specifically documented, but presumably consist primarily of small, surface-schooling fish. Because brown pelican abundance off the Washington coast has been associated with ocean productivity and water temperature, the protection of forage fish populations in Island County may enhance foraging success of pelicans in winter.

Common Loon- Wintering, migrating and non-breeding common loons occur on coastal and inland marine waters of Washington State, and subadult birds often spend the summer in the marine environment. They are most commonly found in shallow, clear, sheltered waters close to shore. The species most often feeds within five meters of the surface but will dive to at least 60 meters to reach clear water (McIntyre and Barr 1997). Common loons require abundant prey (Richardson et al. 2000), and marine habitat use is largely determined by prey availability (Daub 1989, Haney 1990, Ford and Gieg 1995).

Although the existing County code specifically protects nesting habitats of loons, and further identifies loons as a species of local importance, loons are not expected to nest in Island County (Lewis et al. 1999). Loons prefer nesting habitats along large (>12 ha [29.6 acres] in Alaska), clear lakes with islands or convoluted shorelines (Lewis et al. 1999).

Loons may be indirectly affected by upland development through effects to water quality, including bioaccumulation of heavy metals (Alexander 1991) and legacy pesticides (Ream 1976).

Great Blue Heron typically form large colonies near high quality foraging habitats including marine shorelines and shallow streams (Azzerad 2012). Nesting can occur in a range of coniferous and deciduous trees (Azzerad 2012). The species is listed as a species of local importance in the County's code, and is abundant in Island County. Great blue heron are expected to be present on marine shorelines and many of the creeks in all seasons. WDFW data show 13 breeding occurrences of great blue heron in Island County. These occurrences are shown on Map 2.

Great blue herons are vulnerable to human disturbance, predation, and competition for nesting habitat (Azzerad 2012). Although the species may nest in areas with higher levels of human disturbance, human disturbance is associated with reduced nesting productivity and, occasionally, colony abandonment (Azzerad 2012). Bald eagles are the heron's primary predator (Azzerad 2012). Impacts from direct disturbance to nesting or foraging areas or to the prey base, including fish, amphibians, reptiles, invertebrates, and small mammals could adversely affect the species.

Marbled Murrelet- Marbled murrelets are unique in that they forage exclusively in the nearshore and typically nest high in the canopy of old-growth evergreen forests on limbs larger than 10 cm in diameter (Burger 1995, Hamer and Nelson 1995). Marbled murrelet nesting has not been confirmed in Island County, but nesting may occur in mature conifer forests in the County, and possibly, to a lesser extent, in the mature deciduous forested communities documented as occurring within Island County, although no known nest sites have been confirmed. A recently fledged juvenile marbled murrelet was sighted in Penn Cove approximately 6-10 years ago (Steve Ellis, personal communication with Sarah Schmidt, January, 2014). Additionally, marbled murrelets have been observed foraging off of Fort Ebey State Park and Rocky Point on the west side of Whidbey Island (Steve Ellis, personal communication with Sarah Schmidt, January 2014). Marbled murrelets are listed as a protected species in Island County's FWHCA code. Nearshore foraging is also presumed to occur along Island County's shorelines.

Marbled murrelets' nests are difficult to locate because of their small body size, dense forested nesting habitat, cryptic plumage, crepuscular activity, quick flight, and secretive behavior near nests (Hamer and Nelson 1995). Of 45 nests identified in the Pacific Northwest, nest location averaged 16.8 km from marine shorelines, nest stands in the Pacific Northwest averaged 206 ha, although the smallest occupied stand was 3 ha (Hamer and Nelson 1995).

The marbled murrelet population in Washington, Oregon, and Northern California decreased by 30 percent from 2000 to 2010 (Miller et al 2012). The cause of the population reduction is not well understood, but it could be related to habitat fragmentation and/or loss, noise and physical disturbance either on land or in marine foraging areas, or through indirect effects on forage fish populations, among other possibilities. The loss of old-growth forest, and the limited presence of mature deciduous forests in Island County may also be factors that contribute to limited species nesting potential.

Northern Spotted Owl- Spotted owls are uncommon residents in old-growth forests at low to mid elevations of the Cascade and Olympic Mountains. In Washington, the species' range includes the East and West Cascade Range and the Olympic Mountains. The University of Washington and WDFW Cooperative Fish & Wildlife Research Unit's Nature Mapping Program identifies Island County as neither core nor marginal habitat for spotted owl. There are no publically available records of spotted owls in Island County in Seattle Audubon Society's *Sound to Sage Breeding Atlas* or the public database eBird.org. Whidbey Audubon reports two records of spotted owls occurring in Island County. On New Year's Day 1996 a dead spotted owl was found at Fort Ebey State Park. In March 1997 a spotted owl was reported at a residence on Madrona Way near Coupeville. This occurrence was confirmed by three local birders. The spotted owl was captured and relocated by a government agency (Steve Ellis, personal communication with Sarah Schmidt, Whidbey Audubon,

Osprey are common breeders near large bodies of water in western Washington, the PHS data indicate 19 breeding occurrences in Island County. Known nest sites in Island County are shown on Map 2. Osprey are listed as a species of local importance in Island County's code, and their nest sites are protected by code. The great majority of osprey prey items are fish, and only occasionally and out of necessity small mammals, birds, or reptiles. Nests are large structures on top of dead trees or artificially constructed posts near water including power poles, and are normally built upon and used from year to year. A review of work on osprey response to human disturbance found that buffer-zone recommendations for osprey were site-dependent and varied, with a median of 1,000 m (3,281 feet) (Richardson and Miller 1997). Mean flush distances in response to personal watercraft and outboard-powered boats were 49.53m and 57.91 m, respectively, in a more recent Florida study (Rodgers and Schwikert 2001).

Peregrine falcon- Similar to bald eagles, peregrine falcons were recently delisted federally and their Washington status was then changed to Sensitive. Peregrine falcons are listed as a protected species in Island County's code. Nest sites are protected by code. Peregrine falcons feed on smaller birds in a variety of open habitats, and they are particularly associated with marine and lake shorelines (Hays and Miller 1999). Nest sites are most often located on ledges on cliffs over 45 m (150 feet) in height near water (Hays and Miller 1999). The birds are sensitive to disturbance during all phases of the nesting season (1 March through 30 June) (Hays and Miller 1999). PHS data for Island County depict six breeding occurrences of peregrine falcon, but these may include historical records (R. Milner, WDFW, personal communication, December 16, 2013).

Pileated Woodpecker- Pileated woodpecker are listed as a species of local importance in Island County's code. Nest sites are protected by code. WDFW protection measures for pileated woodpecker habitat are included in Section 9.5.2 of this report, and do include protecting suitable nesting, roosting, and foraging habitat. The pileated woodpecker is a primary cavity excavator, creating nest cavities for themselves that are subsequently used by other forest wildlife species. Pileated woodpeckers inhabit old-growth and second-growth forests with large snags and fallen trees (Lewis and Azzerad 2003). Additionally, pileated woodpeckers are residents in remnant forest patches, parks, and greenbelts in developing areas throughout Washington (Lewis and Azzerad 2003). WDFW PHS data depict one breeding occurrence of pileated woodpecker in the county, while the Seattle Audubon Society's *Sound to Sage Breeding Atlas* shows widespread "probable" and "confirmed" occurrences in the County. Because of their need for large trees and their large territory requirements, loss or fragmentation of wooded tracts, large snags, and large trees will impact the species (WDFW 2004). Management activities should focus on providing and maintaining habitat connectivity and a sufficient number of appropriate large snags and large, decaying live trees for nesting and roosting.

Short-tailed Albatross- Short-tailed albatross is an extremely rare visitor of the coast of Washington, and it is not expected to occur in Island County.

Trumpeter Swan- Trumpeter swans are listed as a species of local importance in Island County code. Trumpeter swans are winter visitors to open field and estuaries in western Washington, and the species may use pocket estuaries in the County for foraging and resting. There are no current breeding records in the state. Plant material is the main component of their diet, and their winter diet is mainly upland grasses, cultivated tubers, and waste grain, and thus they may benefit from fallow agricultural fields in winter. Trumpeter swans are documented by WDFW every January as part of an annual swan survey. The greatest numbers (200-400) occur on Camano Island (R. Milner, WDFW, personal communication, December 16, 2013)

Reptiles

Western Pond Turtle- The western pond turtle is locally extinct in Island County (Adamus 2008).

Prairie Species

The species listed below occur in prairie habitats, where the term prairie in this document is used as a general descriptor for wet and dry prairies, herbaceous balds, and herbaceous communities atop coastal bluffs.

Golden paintbrush, a member of the figwort family, is a multi-stemmed perennial herb. It is listed as a protected species in Island County code. Historically, golden paintbrush ranged from the Willamette Valley in Oregon, through the Puget trough, and up to the south end of Vancouver Island in association with prairies (Sheehan 2007). Species collection records indicate that golden paintbrush has a wide habitat preference and was not restricted to well-drained soils historically (Lawrence and Kaye 2006). Prairie vegetation in the Pacific Northwest was historically maintained by anthropogenic fire. Golden paintbrush appears to respond favorably to fire management (Dunwiddie et al. 2000 in Lawrence and Kaye 2006). Today, there are six known locations of natural occurrences of golden paintbrush on Whidbey Island. These include Fort Casey, two areas on Admiralty Inlet Natural Area Preserve (NAP), Hill Road, West Beach and Forbes Point. These locations are shown in Map 3. In addition to its federally threatened and State endangered status, the Department of Natural Resources (WDNR) Natural Heritage Program (NHP) identifies the State conservation status as S1- Critically imperiled.

White–top aster is State sensitive species that forms large colonies connected by rhizomes. It is listed as a protected species in Island County code. There is only one known occurrence of the species on Whidbey Island in an area known locally as Schoolhouse prairie (Erickson, personal communication, January 24, 2014). This occurrence is the only documented population between the prairies of south Puget Sound and the Vancouver Island, British Columbia (Sheehan 2007). The WDNR identifies the species as vulnerable (S3).

White meconella has only been documented at three sites in Washington State, although the species is relatively small, and comprehensive studies have not been completed to document its presence or absence (WDNR 2013). The species was likely aided by historical fire disturbance, and may now be impacted by competition from weedy species. Documented occurrences on Whidbey Island occurred in 1897 and 1936, and more recently plants have consistently been located in the vicinity of Goose Rock in Deception Pass State Park in 2004, 2007 and 2008, although there is significant variation in the number of plants located from year to year (Joe Arnett personal communication, January 6. 2014, see also Arnett. 2013). The WDNR identifies the species as critically imperiled (S1). The species is listed as protected in Island County code.

Taylor's checkerspot (*Euphydryas editha taylori*), a mid-size butterfly, was historically present in prairies of Clallam County, in British Columbia, and on Whidbey Island (Stinson 2005 and Sheehan 2007). This species in not currently known to be present in Island County (Federal Register 2013), although intensive surveys for the species have only recently begun. There are areas of existing suitable habitat in Island County, though these extant habitat patches may not be individually large enough or sufficiently connected to support a persistent population.

Taylor's checkerspot produces a single generation per year. They are a non-migratory species and usually do not disperse very far. Taylor's checkerspot butterflies lay eggs on preferred host plants, which include members of the figwort (Scrophulariaceae) and plantain (Plantaginaceae) families. Larvae feed on one or more host plants and adults require nectar to sustain flight and reproduction. Therefore, viable habitat for Taylor's checkerspot butterflies should include host plants and a variety of nectar sources. This butterfly shows a preference for certain nectar sources, including common prairie plants, such as camas. Habitat heterogeneity, including sparse trees such as Garry oak, topographic variety, and microclimate conditions foster sustainable populations of Taylor's checkerspot, effectively shielding them from seasonal weather extremes (Stinson 2005).

Plant Species Based on Historic Occurrences in the County

The following plant species are included on the County's protected species list in the existing code. They include state endangered, threatened, and sensitive species; and one species (Alaska alkaligrass) that is considered extinct. The most recent documented occurrence of the following species in Island County occurred prior to 1977 (WDNR 2013). As such, it is uncertain whether they persist within the County.

Bulb-bearing water-hemlock- Listed as a state sensitive species, the species is a wetland obligate that is usually associated with organic material, such as logs or sphagnum moss (WDNR 2013). Similar to other species in the Cicuta genus, the species is extremely poisonous.

Black lily- Listed as a state sensitive species, this bulb-bearing perennial herb occurs in moist, open meadows, along lakes and streams, and in sphagnum bogs and salt marshes (WDNR 2013).

Tall agoseris- Listed as a state sensitive species, this flowering perennial occurs in meadows, prairies, open woods, and rocky ridges in California, Oregon, and Washington (WDNR 2013). There are fewer than 50 documented occurrences in Washington. The species is associated with low canopy cover, and likely relied on fire to maintain open, prairie habitat.

Alaska alkaligrass- Listed as a state sensitive species, the species is a glabrous perennial grass that occurs in salt marshes, gravel ridges, moist pockets of gravelly prairies, near marine waters, and in mud flats (WDNR 2013). Fewer than 15 occurrences of the species have been documented in Washington, all of which were prior to 1980 (WDNR 2013). However, systematic surveys have not been conducted to identify potential occurrences.

3.3 Habitats of Local Importance

Habitats identified as Habitats of Local Importance in Island County Code (ICC) are shown in Map 5, and include the following areas which are briefly described below:

- Bos Lake/Swan Lake
- Crockett Lake
- Deer Lagoon
- Newman Ponds[5]
- Cultus Bay Flats
- Whidbey Island Game Farm[6]
- Bos Lake (AKA Swan lake) - Bos Lake is located in the northwestern portion of Whidbey Island, west of the city of Oak Harbor. It is approximately 116 acres in size, and includes open water and wetland habitat, and is proposed to be within 'Natural' shoreline designation in Island County's proposed Shoreline Master Program (the SMP includes a strip of 'Shoreline residential' designation to the west of the lake). The lake is bounded on the west by a road that provides access to the residences located along the shoreline spit. Vegetation around the rest of the lake has been cleared. Land use to the east of the lake is pasture. Bos Lake provides habitat for waterfowl, shorebirds, and a variety of other species. It is considered an Important Bird Area by Whidbey Audubon Society, with 150 documented species occurrences[7]. Whidbey Audubon

[5] Island County's ordinance identifies this area as Newman Road Lakes, but common usage is Newman Ponds. Common usage is employed in this document.
[6] ICC identifies the property as Whidbey Island Game Farm. Since the ICC was adopted, the land has been purchased by the Au Sable Institute, and is now managed by the Pacific Rim Institute. It includes a portion of historic Smith Prairie.
[7] The Important Bird Areas is a program of the National Audubon Society and Bird Life International,

http://web4.audubon.org/bird/iba/
http://netapp.audubon.org/IBA/Reports/275
http://importantbirdareas.blogspot.com/

is currently in the process of conducting bi-monthly bird counts to establish baseline numbers on birds currently using the area, and hopes to receive Important Bird Area designation by the National Audubon Society as a result. It is also a documented breeding area for American Wigeon, Lesser Scaup, and Ruddy Duck, species that rarely nest in Western Washington.[8]

- Crockett Lake- Crockett Lake is located to the east of Fort Casey State Park, on the west side of central Whidbey Island. It is a coastal saline lagoon, approximately 600-700 acres in size, and includes brackish marsh, freshwater marsh, open water, and mudflats.[9] The lake fringe also includes low and high salt marsh, with brackish and freshwater wetlands extending to the east. Hydrology of the lake is controlled by a tidegate that connects Crockett Lake to Admiralty Bay. The tidegate is maintained and managed by Island County Drainage District Number 6 (Herrera, 2007). Freshwater wetlands on the eastern shores of the lake are sustained by groundwater. There is also some freshwater input from ditches to the north. Crockett Lake is proposed as 'Natural' Shoreline, as well as 'Rural Conservancy' designation under the jurisdiction of Island County's proposed Shoreline Master Program. The area around Fort Casey is designated as 'High Intensity' under the proposed SMP. Land use to the north of Crockett Lake is open pasture land. SR 20 is to the south of the lake. Crockett Lake is designated as an Important Bird Area (IBA) of Washington State by the National Audubon Society. 213 bird species have documented occurrences at, or in the vicinity of Crockett Lake.[10] There is a historic occurrence of black lily, (*Fritillaria camschatcensis*) to the east of Crockett Lake, at Admiralty Lagoon (1975).[11] Invasive species, including *Epilobium hirsutum* and *Phragmites australis* are present at the site (Herrera, 2007).
- Deer Lagoon- Deer Lagoon is located on the southwest portion of south Whidbey Island, along the shores of Useless Bay. The lagoon covers approximately 950 acres, and is composed of both freshwater and estuarine wetland, including mudflats and saltmarsh[12]. Wetlands within Deer Lagoon have been significantly altered by historic diking. Deer Lagoon is proposed as containing both 'Natural' and 'Shoreline Residential' designations under Island County's proposed Shoreline Master Program. Deer Lagoon is a designated Important Bird Area (IBA)

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[8] Whidbey Island Audubon Society, IBA nomination form, 2008.
[9] http://www.beachwatchers.wsu.edu/island/estuaries/CrockettLake.htm
[10] Whidbey Audubon, IBA nomination form, 1999.
[11] WNHP PHS data
[12] http://www.beachwatchers.wsu.edu/island/estuaries/DeerLagoon.htm

of Washington State by the National Audubon Society, with documented use by 173 bird species. Deer Lagoon is considered particularly important for use by waterfowl, with concentrations of geese, ducks, and swans far exceeding other locations on Whidbey Island.[13] Deer Lagoon is privately owned. Surrounding land use is residential and agricultural.

- Newman Road Lakes- Locally known as Newman Ponds, this is an approximately 70 acre area located on south Whidbey Island, east of Freeland, and north of Highway 20. It is privately owned and called Earth Sanctuary. This area contains south and southwest facing second and third-growth forested hillslopes and two freshwater wetlands as well as a bog. Surface water flows through the ponds, which are impounded with weirs at the outlet, to the bog, and from there downstream to the south eventually draining to Deer Lagoon. Two of the wetlands on site, known locally as the West and Central Ponds, were created in approximately 1970 by the USDA (Soil Conservation Service) for waterfowl habitat (Earth Sanctuary, 2005). An Osprey nest occurs on site. In addition, cavity-nesting Wood Ducks and Hooded Mergansers are documented nesting on site, using both nest boxes and natural cavities (Whidbey Audubon Society, 2008-2013 Earth Sanctuary Duck Nest Box Usage). The site is privately owned and managed in part for its ecological values. The owners have worked with professionals to create a 500 year management plan for the site (Earth Sanctuary. 2005).
- Cultus Bay Flats- The Cultus Bay Estuary includes approximately 650 acres and is located at the southeastern tip of Whidbey Island. It includes a variety of wetland habitats including freshwater marsh, saltwater marsh, mudflats, and shallow open water.[14] Two streams drain to the bay. Cultus Bay is proposed for 'Natural' shoreline designation under Island County's proposed Shoreline Master Program. Cultus Bay is a winter waterfowl concentration site and provides habitat for a wide variety of waterfowl, including brant.[15] It also includes bald eagle habitat, eelgrass beds, and shellfish beds.
- Whidbey Island Game Farm- Pacific Rim Institute/Au Sable Institute. From the 1940's through the 1995 this 175 acre site was owned and operated by WDFW as a ring-necked pheasant farm. In 1999 the site was purchased by the Au Sable Institute. In 2009, the Pacific Rim Institute, a separate non-profit entity, was established as a subsidiary of the Au Sable Institute. The Pacific Rim Institute intended to purchase the 175 acre site

[13] Whidbey Audubon Society, Deer Lagoon IBA nomination form, 2000. Available electronically at: http://netapp.audubon.org/IBA/Reports/276
[14] http://www.beachwatchers.wsu.edu/island/estuaries/CultusBay.htm
[15] Ruth Milner, WDFW, personal communication 11/22/2013, email.

from the Au Sable Institute in 2013. The site includes a portion of the historic Smith Prairie, so named for the original donation land claim settled by Joseph Smith and his wife Julia in 1971 (Pacific Rim Institute Management Plan, 2013). The site is located within Ebey's Landing National Historic Reserve. A vascular plant species list has been compiled for the site containing 209 species. 95 bird species have been documented at the site. A small portion of the historic Smith Prairie occurs on site and is in 'good' condition (approximately 5 acres). Conservation goals of the site include restoring additional historic native prairie habitat, restoring the conifer forest and prairie forest ecotone on site, restoring habitat for vertebrates and invertebrates using the site, with a focus on prairie birds, and continuing to restore the introduced population of golden paintbrush at the site, which was documented to have over 12,000 plants in June of 2012 and thus represents the most successful introduced planting of this species globally. (Pacific Rim Institute Management Plan, 2013). Erickson notes that final plant counts of the introduced population of golden paintbrush were in excess of 16,000 plants (Steve Erickson, personal communication, January 24, 2014).

- Penn Cove- Penn Cove is the bay to the north of the town of Coupeville. It encompasses 12 miles of shoreline, including Grasser's Lagoon, and Kennedy's Lagoon, on its western shores. Penn Cove is known for aquacultural production. The northern portion of Penn Cove is also mapped as a Pacific sand lance spawning area. Penn Cove is an important area for waterfowl and shorebirds, and its tidal flats and coastal lagoons support important rearing and refuge habitat for juvenile salmonids. Penn Cove is designated as an Important Bird Area of Washington State by the National Audubon Society with 102 species' documented occurrence, including 3 species of loons, 4 species of grebes, 19 species of ducks and other waterfowl[16]. Penn Cove is listed as a winter waterfowl concentration site by WDFW, and is an important area for scoters.[17]
- Hastie Lake- Hastie Lake is located in the northern half of Whidbey Island, north of Penn Cove and west of Highway 20. Vegetation around the lake has been cleared. A County boat ramp and parking area occur on .7 acres of land adjacent to the lake. Land use surrounding the lake is rural residential. Hastie Lake has silted in in recent years, and is likely classified as a wetland with a palustrine open water component (with areas of open water less than six feet in depth) (Island County staff,

[16] Whidbey Island Audubon Society, Penn Cove IBA nomination form, 2000. Form available on line at: http://netapp.audubon.org/IBA/Reports/285

[17] Ruth Milner, WDFW Habitat Biologist, personal communication, email, 11/22/2013

personal communication). Hastie Lake provides habitat for waterfowl as well as other bird and amphibian species. No systematic inventories of plant or animal species are known to exist for Hastie Lake.

- Useless Bay- Useless Bay is located in the southwest portion of south Whidbey Island. Deer Lagoon, described above, comprises the northern shoreline of Useless Bay. When combined, Deer Lagoon and Useless Bay encompass nearly 7 miles of shoreline and 729 acres of area. Numerous streams drain to Useless Bay from the east, north, and northeast (from Lone Lake). Useless Bay is included as part of the designated IBA, and provides important waterfowl and shorebird habitat. Geoduck beds and patchy eelgrass beds occur within the Bay. Eelgrass beds frequently draw flocks of Brant geese to forage and roost in the area (Sarah Schmidt, Whidbey Audubon Society, personal communication, January 24, 2014). The area is also documented as a known location for Great Blue Heron and a Bald eagle nest (see Map 5). Significant feeder bluffs flank the western shores of Useless Bay.

3.4 Streams

In general, freshwater streams will be managed under the County's Fish and Wildlife Habitat Conservation Area regulations. Streams are defined in ICC 17.02.030 as follows:

> "*Those areas where naturally occurring surface waters produce a defined channel, bed, bank or side, and where there is clear evidence of the passage of water such as bedrock channels, gravel beds, sand and silt beds and defined channel swales. The channel or bed need not contain water year-round. This definition is not intended to include irrigation or drainage ditches or swales, canals, storm or surface water run-off devices or other artificial watercourses unless they are used by salmonids or to convey streams naturally occurring prior to construction of such watercourses.*"

There are no streams classified as Shorelines of the State in Island County (>20 cfs); however, where any stream passes through shoreline jurisdiction (extending 200 feet landward of marine shorelines or lakes over 20 acres, and including associated wetlands) or is influenced by tides, it will be managed under the SMP once it is adopted under Ecology's 2003 Shoreline Master Program Guidelines.

Most streams in Island County are intermittent or ephemeral. Anadromous salmonid spawning has been documented on Whidbey Island in the following creeks: Dugualla, Swantown, Crescent, North Bluff, Honeymoon, Useless, Maxwelton, Quade, Scatchet, Cultus, Glendale, Deer, Old Clinton, Sandy Point and Langley, and on Camano Island in the following creeks: Kristoferson, Cavalero, Carp, Chapman and Cama as shown on Map 6. No comprehensive effort has been undertaken to ascertain the extent of salmon spawning in Island County streams. The lack of spawning in suitable streams may be a result of fish passage barriers (example: Old Clinton Creek). Coho salmon have been supplemented sporadically in Maxwelton Creek since 1956, although no supplementation has occurred since 2003 (Robin Clark, personal communication, January 24, 201although no supplementation has occurred since 2003 (Robin Clark, personal communication, January 24, 2014). Natural spawning occurs in Maxwelton, and this Creek has been noted in planning documents as an independent population (SRP 2005). Other basins may also support independent stocks that have not yet been documented. For example, redds and coho fry with egg sacks were recently documented in Zook Creek (Beamer et al. 2013)

3.4.1 Special Consideration to Anadromous Fisheries

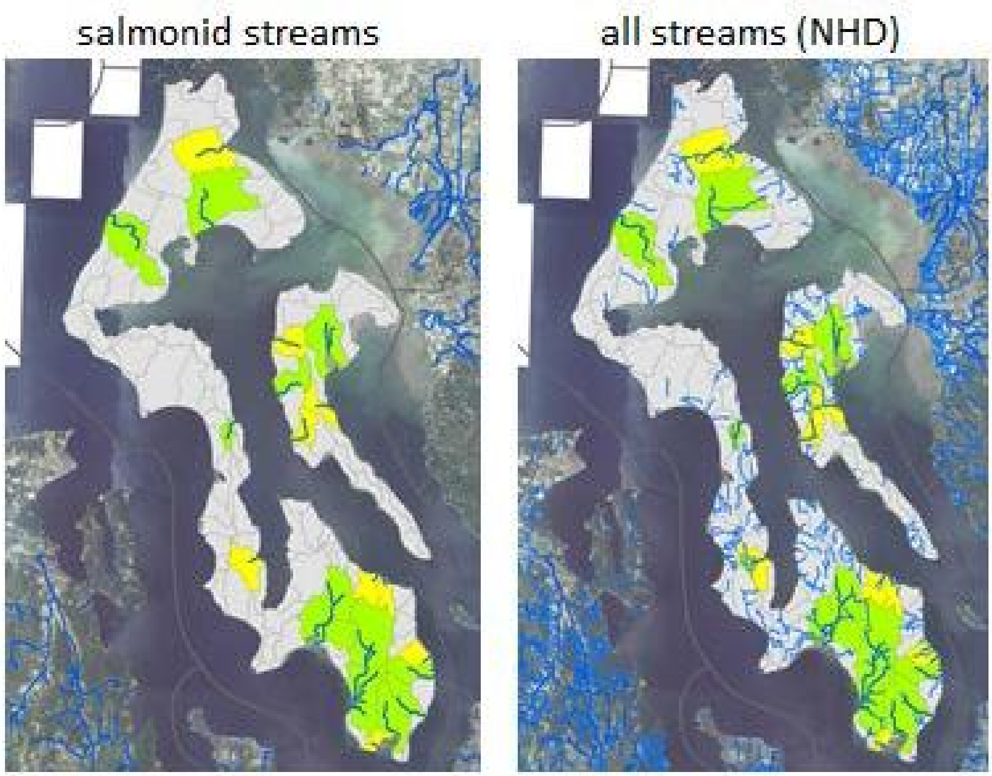

Figure 2. Anadromous Fish-bearing Streams and All Streams in Island County

As previously noted, the GMA requires 'special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries (RCW 36.70A.132(1)). The map on the left in Figure 2 shows streams with documented salmonid usage by WDFW using the freshwater habitats model from the Puget Sound Characterization Watershed Characterization Project Volume 2 (Wilhere et al. 2013).

The freshwater habitat assessments model focuses on connectivity of the freshwater system. Therefore, it considers how materials upstream (water, wood, sediment) are transported to the mouth of the system. Reach quality is affected by stream connectivity, and the model includes an assessment of relative conservation value both upstream and downstream within each assessment unit. In addition, the map focusses heavily on the presence of salmon, which have been the focus of significant conservation planning work in the Puget Sound region over the last decade; salmon are considered an umbrella species, although the authors caution that the results should be supplemented by WRIA-specific planning which is more locally focused than the Puget Sound model (Wilhere et al. 2013). The assessment units noted in green have a higher relative conservation value than those shown in yellow.

The GMA directs local governments to "consider recommendations found in salmon recovery plans…to designate, protect, and restore salmonid habitat' (WAC 365-190-130(4)(i). In 2005 Island County adopted the WRIA 6 Multispecies Salmon Recovery Plan (SRP, 2005). The WRIA 6 Multispecies Salmon Recovery Plan establishes geographic priority areas for salmon restoration within Island County. The geographic priorities from the Plan are reproduced below:

> ***"Geographic Area 1*** *(top priority) includes the WRIA 6 sub-basins and shorelines of Deception Pass, Skagit Bay, and Port Susan. These shorelines are within ~5 miles of the mouths of the Skagit, Stillaguamish, and/or Snohomish rivers. This area is utilized by the largest number of Chinook fry migrants, from these rivers, during their first day of nearshore migration. The shorelines are primary pathways for bull trout migrating between these rivers. And the area is used heavily by juveniles and adults from the 47 salmon and trout stocks that originate in these rivers; over 20% of the stocks in Puget Sound."* The following salmon-bearing streams occur within Geographic Area 1:
>
> - Dugualla Creek
> - Kristofferson Creek
> - Cavalero Creek
>
> ***"Geographic Area 2*** *(medium priority) includes the WRIA 6 sub-basins and shorelines of Saratoga Passage, Possession Sound, Southeast*

Admiralty Inlet (Double Bluff to Possession Point), and Northwest Whidbey (Deception Pass to the north end of West Beach). The Saratoga Passage and Possession Sound shorelines and sub-basins were included because they are within the Whidbey Basin, which is an area that has been regionally recognized as important to all south and central Puget Sound stocks. Southeast Admiralty Inlet was included because this section of the south Whidbey coast is likely to be used by juveniles from a large number of south and central Puget Sound stocks and part of this area is included in the bull trout critical habitat definition. Northwest Whidbey was included because it is adjacent to the top priority area and it is included in the bull trout critical habitat definition." The following salmon-bearing streams occur within Geographic Area 1:

- Crescent Creek
- North Bluff Creek
- Honeymoon Creek
- Useless Creek
- Maxwelton Creek
- Quade Creek
- Scatchet Creek
- Cultus Creek
- Glendale Creek
- Deer Creek
- Old Clinton Creek
- Sandy Point Creek
- Langley Creek
- Carp Creek
- Chapman Creek
- Cama Creek

"Geographic Area 3 *(lower priority) includes the WRIA 6 sub-basins and shorelines of the west side of Whidbey, south of West Beach and north of Double Bluff. This area has been given low priority because it is not adjacent to any of the rivers with natal populations and it is at the entrance to Puget Sound and most habitats are impacted by high wave energy and current energy. It is hypothesized that West Whidbey habitats function primarily as migration corridors and for food production for larger juveniles and returning adults" (SRP, 2005).* Swantown Creek is located within this Geographic Priority Area.

While all streams are regulated within Island County, the geographic prioritization adopted as a part of the WRIA 6 Multispecies Salmon Recovery Plan could be considered as an overlay onto existing regulations related to protecting and prioritizing salmon habitat restoration and protection within the County. However, it should be noted that the geographic priorities in the Salmon Recovery Plan have not been updated to include new data regarding salmonid presence in and around Island County as noted in Beamer et al. (2013), and discussed in this report.

Recent research has documented non-natal salmonid use of the lowermost portions of 16 out of 32 streams sampled in Island County. This finding indicates an underappreciated function of many presumed non-fish bearing streams in the County. Based on statistical analyses, juvenile Chinook are likely to be found in accessible streams within basins that are larger than 111 acres, with a channel gradient less than 6.5%. Streams that are closer to natal rivers (Skagit, Snohomish and Stillaguamish) are more likely to be used by juvenile Chinook (Beamer et al. 2013). This suggests that small watercourses in Island County may support juvenile Chinook salmon originating in watersheds outside of Island County. Results of this study are shown on Map 6.

Resident fish, including resident cutthroat trout, have been documented in Maxwelton, Glendale, North Bluff, Dugualla, and Chapman Creeks. Another 10 watersheds have been identified as having potential to support salmonid populations (WSCC 2000). Map 6 shows salmonid-bearing streams as documented in Island County. Map 7 shows non-salmonid bearing streams in Island County.

3.5 Ponds and Lakes

Direct effects to lakes will be managed by the County's Shoreline Master Program. Lakes are currently defined in ICC 17.02.030 as follows:

> "*A lake twenty (20) acres or greater in size which is subject to the provisions of the Shoreline Management Act (Goss Lake, Lone Lake, Crockett Lake, Deer Lake, Kristoferson Lake, Cranberry Lake), and three (3) unnamed lakes located in Section 24, Township 29N, Range 2E (26 acres); Section 6, Township 31N, Range 1E (25 acres)*."

It should be noted that Island County's Shoreline Master Program, currently under review by Washington's Department of Ecology, states that shorelines of the state are comprised of marine waters surrounding eight islands (Whidbey, Camano, Baby, Ben Ure, Deception, Minor, Smith, Strawberry), coastal lagoons: Admiral's, Bush Point, Crockett, Deer, Harrington, Kennedy's, Lake Hancock, Perego's, Race, Swan Lake, Twin Lake; fresh water lakes including Cranberry, Deer, Dugualla, Goss, Kristofferson, and Lone." If adopted as proposed, Crockett Lake would be considered a coastal lagoon under shoreline jurisdiction, and Dugualla Lake would also be regulated under the proposed Shoreline Master Program.

It is presumed any natural ponds and lakes in the County support some level of fish and/or wildlife use, and these will be managed under the County's FWHCA regulations. Ponds or lakes less than six feet deep and less than 20 acres in area that include aquatic bed vegetation are wetlands, and would also be managed under the County's wetland regulations (ICC 17.02A.090). The County's existing FWHCAs regulate deepwater habitats, defined as open water areas deeper than 6 feet that are not lakes. Several wetlands in the County are man-made ponds or are associated with man-made ponds (Adamus 2007). Where these ponds were created in naturally occurring wetlands, human alterations have changed the previously occurring vegetative, habitat, and hydrologic functions. Newman Ponds are examples of large open water areas that are not regulated under shoreline jurisdiction, but would be regulated under FWHCAs, as well as under the County's wetland ordinance. Newman Ponds are a designated Habitat of Local Importance, and discussed in more detail above.

Ponds and lakes in the County are important foraging areas for species including bald eagles, osprey, peregrine falcon, and great blue heron. Larger lakes may also be used by trumpeter swan. Several lakes in the County support freshwater fish populations. WDFW stocks some lakes on Whidbey Island (e.g., Deer Lake, Cranberry Lake) with rainbow trout to support recreational fisheries.

3.6 State Natural Area Preserves and Natural Resource Conservation Areas

The only Natural Area Preserve (NAP) in Island County is the Admiralty Inlet NAP, located within Ebey's Landing National Historical Reserve. The NAP is jointly owned by the WDNR and Whidbey Camano Land Trust. The NAP protects one of only 10 remaining populations of golden paintbrush in Washington State (Arnett 2013). Golden paintbrush is a federally threatened plant species. The area includes a 36-acre old growth forest, as well as shoreline bluffs. PHS data show the presence of bald eagles nests within the Reserve, and eBird records include sightings of common loon, great blue heron, marbled murrelet, and osprey. The cliffs, also documented by WDFW as a Priority Habitat, may be suitable for peregrine falcon nesting, and the species has been reported there on several occasions by eBird users.

Island County does not presently have any lands designated as Natural Resource Conservation Areas.

3.7 Washington Department of Natural Resources (WDNR) Natural Heritage Program (NHP) Sites

Natural Heritage Program sites identify vulnerable plant locations and significant native plant communities in the County as shown on Map 3.

3.7.1 Natural Heritage Program Communities

Freshwater wetlands must meet the following six criteria to be included in as a NHP site.

1. Contains a native wetland ecosystem type (Element) considered important for preservation within the state.
2. Little or no human-caused changes to wetland topography or soils.
3. No human caused changes to hydrology of the wetland, or the wetland appears to have recovered from any changes.
4. Few or no exotic plant species.
5. Little human-caused disturbance of native vegetation, or vegetation has recovered from past disturbance.
6. No major water quality problems.

Terrestrial communities must meet the following three criteria to be included:

1. Native plants dominate the site: tree layers composed of only native species.
2. Little or insignificant disturbance to vegetation by logging, conversion to agriculture, heavy grazing, residential development, or other recent human extractive activities that alter the ecosystem processes.
3. Large enough for minimal viability and ecological function: at least 20 acres for forest in the Puget Lowlands, and at least 10 acres for native grasslands.

The County's existing FWHCA regulations reference NHP sites within Island County, depicted on a map dated October 11, 1999. The NHP sites depicted on that map generally correspond with all NHP sites presently identified in Island County, and presumably, any discrepancies are a result of the identification of additional NHP sites since 1999. This information is updated on Map 3.

NHP sites in Island County can be generally categorized into 6 habitat classes, described below. Unless otherwise noted, descriptions of the vegetation communities come from Chappell's *Upland Plant Associations of the Puget Trough Ecoregion, Washington* (2006) and Kunze's *Preliminary Classification of Native, Low Elevation Freshwater Wetland Vegetation in Western Washington* (1994).

State rankings of each community are also included. It should be noted that the vulnerability of State rankings are described by the NHP as follows:

- **S1 = Critically Imperiled** - At very high risk of extirpation in the state due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.
- **S2 = Imperiled** - At high risk of extirpation in the state due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
- **S3 = Vulnerable** - At moderate risk of extirpation in the state due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
- **S4 = Apparently Secure** - At a fairly low risk of extirpation in the state due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
- **S5 = Secure** - At very low or no risk of extirpation in the state due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats.

Sphagnum Bogs

Sphagnum bogs tend to occur in depressions where surface water inflow and outflow are limited. They also occur as pockets as floating mats or islands within wetlands with mineral soils. Living Sphagnum spp. typically dominate the soil surface, and can be intermixed with other moss species. Bogs are sensitive to compaction, changes to hydrology, and changes to water quality (e.g., Grigal and

Brooks 1997, Hruby 2004). Once altered, recreating bogs is extremely difficult (Hruby 2004). In Island County, water quality changes and former mining of peat have resulted in the conversion of some bogs to open water wetlands. WNHP maps six bogs occurring in Island County, though there are likely more which have not been documented. (For example, Erickson reports a bog with a floating mat component occurring at Earth Sanctuary (Steve Erickson, personal communication, January 24, 2014). The bog that occurs on the Earth Sanctuary property is not mapped by WNHP data). The bog communities mapped by WNHP include two different types around Cranberry Lake on the northwestern corner of Whidbey Island (one Shore Pine/Bog Labrador-tea and Sphagnum community (S2), and one low elevation sphagnum bog (S2), and four additional bog community types on the northeastern portion of Whidbey Island. These bogs are mapped by WNHP as bog Labrador-tea/Bog Laurel and Sphagnum (S3), Bog Laurel/Bog Labrador-tea and Spaghnum (S3), and two low elevation sphagnum bogs (S2).

Natural Heritage Program-designated sphagnum bog communities in Island County include the following.

- Bog Labrador-tea - Bog-laurel / Sphagnum Spp. (S3-Vulnerable)
- Shore Pine / Bog Labrador-tea / Sphagnum Spp. (S2- Imperiled)

Freshwater Wetlands

The County's freshwater wetlands are addressed in detail in the Best Available Science for Wetlands of Island County, Washington: Review of Published Literature (Adamus 2007). Natural Heritage Program-designated wetland communities in Island County include the following.

- Baltic Rush (S3/S4- Vulnerable/ Apparently Secure)
- Broad-leaf Cattail (S5- Secure)
- Common Marestail (S2- Imperiled)
- Yellow Pond-lily (S4/S5- Apparently Secure/ Secure)
- Douglas' Spirea (S5- Secure)
- Willow Spp. (S3- Vulnerable)
- Buckbean (S4- Apparently Secure)
- Red Alder / Salmonberry / Slough Sedge – Skunk cabbage (S3/S4 Vulnerable/ Apparently Secure)

Estuarine Wetlands

Estuarine wetlands span a range of tidal influence and salinities, and tidal marsh communities vary depending on the frequency of inundation and salinity exposure. Many of the historical estuarine wetlands in Island County and Puget Sound have been lost as a result of shoreline development (McBride and Beamer 2010, Fresh et al. 2011, Schlenger et al. 2011, Simenstad et al. 2011).

Natural Heritage Program-designated estuarine wetland communities in Island County include the following.

- Pickleweed (S2- Imperiled)
- Pickleweed - Saltgrass - Seaside Arrowgrass - (Fleshy Jaumea) (S2-Imperiled)
- Saltgrass - (Pickleweed) (S2- Imperiled)
- Sandy, High Salinity, Low Marsh (S2- Imperiled)
- Sandy, Moderate Salinity, Low Marsh (S1- Critically imperiled)
- Silty, Moderate Salinity, Low Marsh (S2- Imperiled)
- Transition Zone Wetland (S1- Critically Imperiled)

Coastal Spit Vegetation

Like estuarine species, coastal vegetation communities are adapted to tolerate salt-air. Coastal vegetation communities have been affected by shoreline fill and development. Natural Heritage Program-designated coastal plant communities in Island County include the following.

- American Dunegrass - Japanese Beachpea (S2- Imperiled)
- Bighead Sedge (S1- Critically Imperiled)

Broadleaf Forests

Natural Heritage Program-designated deciduous forest habitats in Island County include the following.

- Bigleaf Maple - Red Alder / Swordfern - Fringecup Community (S2-Imperiled)

  These sites are typically located on steep slopes, usually adjacent to saltwater. The vegetation community is adapted to frequent landslides. This vegetation community, which is naturally limited in its range and geographical area, has been impacted by development and non-native species invasions. The South Camano Island Bigleaf Maple – Red Alder/Swordfern – Fringecup community encompasses approximately 108 acres, and is documented on Map 3. Protection Standards within this community are also specifically identified within ICC.17.02a.C.6.

- Oregon White Oak / Common Snowberry / Long-stolon Sedge (S2- Imperiled)

  This vegetation community is associated with dry habitats with nutrient-rich soils. These sites are likely the result of an increase of native understory shrubs in oak woodlands, or of oak invasion onto former prairies in the absence of periodic fires. Because of the occurrence of fires in the historic landscape, this habitat type may have been rare or absent. In the absence of fire or active management, Douglas-fir trees tend to establish and eventually convert the habitat to conifer forest. Few high quality sites remain in the state, and only one occurs in Island County as shown on Map 3. The viability of remaining sites is highly threatened by non-native species, conifer encroachment, and development.

- Red Alder / Swordfern (S4- Apparently secure)

  This species assemblage is expected to occur more commonly today compared to historic conditions, as it is generally associated with vegetative regeneration following timber harvest. Historically, this assemblage likely occurred following fires and windthrow disturbances.

Douglas-fir – Pacific Madrone Forests

These sites are rare in Washington State. They typically occur on steep, relatively dry, sunny slopes adjacent to saltwater shorelines. They are characterized by a Douglas-fir overstory,

Natural Heritage Program-designated conifer forest habitats in Island County include the following.

- Douglas-fir - Pacific Madrone / American Purple Vetch (S1/S2 Critically imperiled/imperiled)
- Douglas-fir - Pacific Madrone / Salal (S2- imperiled)

Douglas-fir – Western Hemlock Forests

These forests provide nesting and foraging habitat for many of the threatened, endangered, and sensitive bird species in the County, as well as for numerous more common bird species.

Douglas-fir tends to dominate the upper canopy layer at these sites, and western hemlock is co-dominant and dominates tree regeneration. Western redcedar is sometimes prominent. The shrub layer ranges from sparse to moderately dense. These sites tend to occur in moderately dry areas. The historical abundance and connectivity of these systems have been reduced by logging and production of conifer plantations. Logging and plantation forestry have reduced tree canopy diversity and the abundance of coarse woody debris. The practices have also truncated natural successional processes, limiting expression of late-seral characteristics. Logging and development continue to be threats to the remaining intact stands. The Douglas-fir – Western Hemlock/Pacific Rhodendron- Evergreen Huckleberry community is endemic to the Puget Trough region, and only five known sites support this community. WNHP-mapped sites of this community are shown on Map 3. Keystone is identified by Island County's ordinance as occurring within a WNHP mapped significant plant community dominated by Douglas fir, western hemlock, and swordfern.

Natural Heritage Program-designated Douglas-fir – Western Hemlock forest communities in Island County include the following.

- Douglas-fir - Western Hemlock / Dwarf Oregongrape (S1- Critically imperiled)
- Douglas-fir - Western Hemlock / Evergreen Huckleberry (S2- Imperiled)
- Douglas-fir - Western Hemlock / Oceanspray / Swordfern (S2- Imperiled)
- Douglas-fir - Western Hemlock / Pacific Rhododendron - Evergreen Huckleberry (S2- Imperiled)
- Douglas-fir - Western Hemlock / Salal (S2- Imperiled)
- Douglas-fir - Western Hemlock / Swordfern (S2- Imperiled)

Douglas-fir Forests

These sites are similar to Douglas-fir –Western Hemlock communities, except that little to no western hemlock, western redcedar, or grand fir is present. Only 17 good quality sites remain in Washington. Most sites have been affected by logging or development. These sites are characterized by Douglas-fir / Salal – Oceanspray community, a State imperiled (S2) community.

Prairies and Oak Woodlands

Prairie habitat throughout Western Washington is one of the most imperiled habitat types, and a number of rare plant species are associated with this habitat type (Floberg et al, 2004, WDFW, 2005). Formed in glacial outwash soils, grassland- dominated 'prairies' (so called by the first European settlers), scattered with oak trees, were maintained through fire by the native American tribes prior to European settlement (Boyd, 1999). The Tribes maintained the prairies with fire management for food production (cultivating a variety of roots, including camas, chocolate lily, bracken fern, acorns), as well as to maintain the open grasslands, which in turn provided habitat for deer and other species (Gibbs, 1877 cited in Boyd, 1999). Five major Skagit villages were known to occur in the vicinity of modern day Oak Harbor, along Crescent Harbor, and Penn Cove (White cited in Sheehan, 2007). The open grasslands of the prairies also supported spectacular wildflower displays noted by the early settlers (Boyd, 1999, Sheehan, 2007). In addition, the open prairies were among the first areas to be claimed by European settlers as part of the earliest wave of modern development which began in the 1850's. Sheehan notes that the earliest land claim donations coincided with the known prairie areas on Whidbey Island (Sheehan, 2007). Nearly all of the historic habitat type existed from Central Whidbey Island (just north of Crockett Lake) north to what is currently the town of Oak Harbor and Whidbey Island Naval Air Station, to the northwest.

Only about 5 percent of the soils in Island County are made up of prairie soils (Ness and Richins 1958). Prairie soil types as defined by Ness and Richins encompass approximately 7,600 acres (Sheehan, 2007). Most prairies and oak woodlands in Island County were lost as land was converted to other uses, including agriculture, military operations, and residential and urban development. Today on Whidbey Island, only small patches of prairies and oak woodlands persist. Sheehan (2007) documented six small prairie patches with golden paintbrush and one oak woodland site on Whidbey Island: 1) Naas (Admiralty Inlet) Natural Area Preserve, 2) West Beach site, 3) NAS Whidbey Island-Seaplane Base – Forbes Point site, 4) Fort Casey State Park Site, 5) Smith Prairie, and 6) Grasser's Hill. These areas are shown on Map 3. There are, however, additional areas of remnant prairie vegetation within Island County. For example, the Whidbey Island survey (Sheehan 2007) omitted coastal locations, such as Ebey's Bluff. Additionally, the Grasser's Hill site, located on a south-facing slope above Penn Cove, is actually made up of two prairie remnants, Grasser's Hill and Schoolhouse Prairie. These two remnants differ in vegetative composition, soil, ownership(s), and protective status. Schoolhouse Prairie is designated a critical area due to the presence of a small population of white-topped aster, a State-listed sensitive species. Grasser's Hill contains the only known population of blue flag iris on Whidbey Island and Western Washington, Oregon, and British Columbia (Steve Erickson, personal communication, January 24, 2014). This blue flag iris population is partially within a National Park Service (NPS) Scenic Easement that is enrolled in the Public Benefit Rating System (PBRS). Protection of the blue flag iris is one of the conditions this program. A management plan was developed in 2004 by Island County Public Works, but the implementation status of the management plan is currently unknown (Island County staff, personal communication). Other rare prairie species known to occur on Grassers Hill include Roemer's fescue, congested snakelily (possibly now extirpated from Island County), and chocolate lily (Sheehan 2007). White top aster was documented as occurring at the Schoolhouse prairie site in 2002, in the general vicinity of Grasser's Hill (Joe Arnett, personal communication, January 6, 2014). Due in part to the presence of extant prairie species, Grasser's Hill also contains potential habitat for the federally endangered Taylor's Checkerspot (Sheehan 2007).

A portion of Smith Prairie was formerly a Department of Fish and Wildlife Game Farm facility, and is designated by Island County as a Habitat of Local Importance. The former Game Farm is now under ownership of the Au Sable Institute, and portions of the prairie are now being restored. As a result of prairie conservation projects over the last decade, golden paintbrush was introduced and is now present in the former Game Farm. Smith Prairie, located within Ebey's Landing National Historical Preserve, now contains the federally and State threatened golden paintbrush, and potential habitat for the federally endangered Taylor's Checkerspot.

Soil composition in former prairies ranged from high to low productivity and some coastal sites also received salts from sea spray (Lawrence and Kaye 2006). According to historic records, prairies on highly productive soils were characterized by camas, bracken fern, nettle and strawberries. Prairies with less productive soils contained bracken fern and a variety of wildflowers, including camas, lupines, wild onion, paintbrush, and goldenrod (Sheehan 2007).

Natural Heritage Program-designated prairie habitats are shown on Map 3 in Island County and include the following.

- Red Fescue - Great Camas - Oregon Gumweed (S1- Critically imperiled) (coastal)
- Red Fescue - Silver Burweed (S1- Critically imperiled) (coastal)
- Roemer's Fescue - Field Chickweed - Prairie Junegrass (S1- Critically imperiled)

3.7.2 NHP Plant Sites

NHP-designated plants sites are identified in Island County for several species noted in Section 2.1, including golden paintbrush (2 sites), white-top aster (1 site), and white meconella (1 site). In addition to these species, one NHP site is identified in Island County for each of the following plants: true babystars (SU- unrankable due to lack of information or substantially conflicting information about status or trends), niebla lichen (S1- critically imperiled), and flavoparmelia lichen (SNR- unranked). NHP-designated plant sites are shown on Map 3.

3.8 Marine Shorelines of Significance

Direct effects to marine shorelines will be managed by the County's SMP. The SMP applies to all areas within 200 feet of marine shorelines and areas of tidal influence, including associated wetlands. Designated Habitats of Local Importance within the Marine Shoreline include Crockett Lake, Deer Lagoon, Cultus Bay Flats, Penn Cove, and Useless Bay, which are discussed in greater detail above.

WDFW provided the map sets above. The map on the left shows Marine Shoreline Habitat Assessments using Volume 2 of the Puget Sound Characterization. The different background layers in the waters surrounding Island County denote varying oceanographic sub-basins. The dark blue is the oceanographic sub-basin surrounding Camano Island and the mainland, the grey is the oceanographic sub-region surrounding the west side of Whidbey Island and the Olympics Peninsula, while the turquoise oceanographic sub-basin comprises the San Juan Island shorelines. The effect of this is that shorelines within each of these sub-basins are compared to each other, so the relative importance (as denoted by the green, yellow, red, meaning high to low value), is as compared to other shoreline segments within that oceanographic sub-basin. Shoreforms and shore zones are broken out by geomorphic structure within each sub-basin (e.g., beach, bluff, cove, the type of bluff, the type of vegetation). The darkest green color indicates shorelines with the highest species richness (according to the available data), while the red indicates the lowest species richness, within each oceanographic sub-basin. There are some known data gaps (for example, juvenile salmonid use of the shoreline was not considered). However, species data for 41 species is considered in the model, and is described in Appendix D of Volume 2 of the Puget Sound Watershed Characterization Habitat Assessment Models.

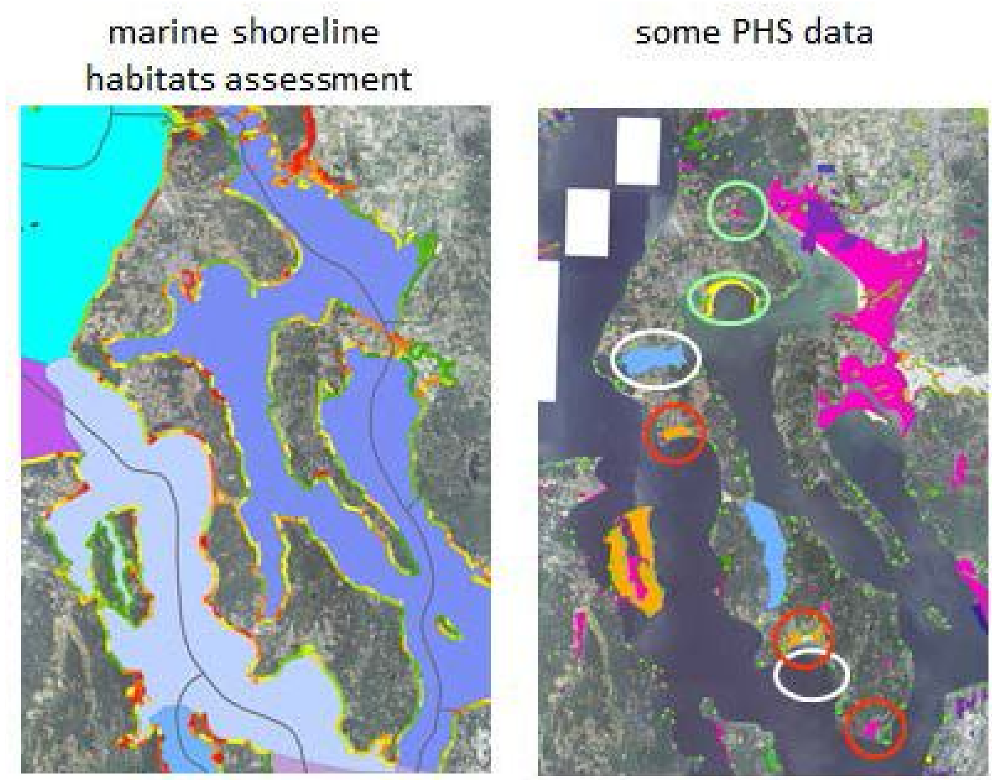

Figure 3. Marine Shoreline Habitat Assessments

The map on the right shows existing designated Habitats of Local Importance, circled in red and white, and areas of significant habitat use in the marine shoreline circled in light green (Dugualla Bay is documented as a concentrated shorebird use area, while WDFW noted that Crescent Harbor is documented habitat used by harlequin duck, as also shown in Map 2). Whidbey Audubon notes that Crescent Harbor is significant for its use by Black Oystercatchers and Northern Harriers (Sarah Schmidt, personal communication, January 24, 2014).

An expanded discussion of the results of the marine shoreline habitat assessment is beyond the scope of this analysis (because they are all in shoreline jurisdiction under the County's proposed SMP). However, what this map set illustrates is that there are significant areas of habitat within the marine shoreline that rank more highly than those currently designated as Habitats of Local Importance. Further, many of the existing designated Habitats of Local Importance coincide with both wetland and marine shoreline areas. It is unclear what additional protection status is afforded to existing designated Habitats of Local Importance by the current ordinance that would not otherwise be provided either by existing wetland regulations or proposed shoreline regulations.

The County should consider revising its Habitats of Local Importance designation process as part of its policy updates in the 2016 Comprehensive Plan, Natural Lands Element. Designation of Habitats of Local Importance should be based on consideration of existing habitats and species, and the functions provided by those habitats and species, and should include consideration of the relative value of habitats as determined by existing models and local data. Protection standards based on the needs of the habitats and species in question can then be developed for each area. The County may choose to identify and designate Habitats of Local Importance that are also otherwise protected, but the rationale for these designations should be transparent.

Approximate locations of shellfish beds and beaches, kelp and eelgrass beds, and documented forage fish spawning areas, all of which are designated as Fish and Wildlife Habitat Conservation Areas, and which occur within or adjacent to the County's marine shorelines are shown on Map 2. The FWHCA regulations will be important in managing potential indirect effects on these areas from land use actions or changes outside of shoreline jurisdiction. Potential indirect effects of actions outside of shoreline jurisdiction include changes in transport of sediment, large wood, and organic material or changes that affect water quality.

Forage fish spawning areas

Forage fish are central to the marine food web of the Puget Sound. Forage fish spawning in the nearshore areas of Island County include Pacific herring, surf smelt, and Pacific sand lance.

Herring predominantly spawn in shallow subtidal waters on eelgrass, as well as on kelp and other available surfaces. Herring near Island County's shorelines typically spawn between January and April (Bargmann 1998, Penttila 2007). Herring spawning in Island County is concentrated in Skagit Bay at the northwest end of Whidbey Island, in Holmes Harbor, and on the eastern shoreline of Camano Island (Penttila 2007). Factors such as water temperature and river discharge can affect spawning success.

Both Pacific sand lance and surf smelt spawn during high tides on in the upper intertidal zone. Both species require a beach area and sand and gravel substrate suitable for spawning (Penttila 2007). Surf smelt and sand lance eggs adhere to sediment, and require wave action to disperse and cover the eggs with a fine layer of substrate (Parks et al. 2013). Spawning of Pacific sand lance is concentrated between November and February (Bargmann 1998), whereas surf smelt spawning occurs year-round in Island County (Penttila 2007). Unlike herring, the mapped spawning sites of sand lance and surf smelt are distributed fairly evenly all across the lower energy shorelines of Island County, and there is no obvious separation of spawning stocks or aggregations (Penttila 2007). Spawning areas are concentrated on the east side of Whidbey Island, and around Camano Island in lower energy environments, although some spawning does occur in bays and in some beaches on the west side (Robin Clark, personal communication, January 24, 2014).

Commercial and recreational shellfish beds

Shellfish Growing Areas in Island County include Holmes Harbor, Penn Cove, Port Partridge, Port Susan, Possession Sound, Saratoga Pass, South Skagit Bay, and Southwest Whidbey Island. Of the 56 public beaches in Island County, 17 were closed due to pollutants, and 17 had a harvest advisory in 2013 (WDH, electronic reference). Shellfish growth can be affected by fine sediment loads and salinity. Pathogens and toxic algal blooms are related to water quality from upland uses, and they can present health hazards from shellfish consumption (Anderson et al. 2002).

Kelp and eelgrass beds

Kelp and eelgrass beds provide habitat for invertebrates and diverse fish assemblages, including juvenile and subadult salmonids (e.g., Hosack et al. 2006, Hayes et al. 2011). Kelp and eelgrass beds also entrain sediment and detritus, and are a major organic carbon source in nearshore areas (Miller et al. 1980, Steneck et al. 2002). Kelp requires high ambient light, hard substrate, minimum turbidity during settlement, and fairly low marine water temperatures and moderate to high salinities (Mumford 2007). Eelgrass beds similarly require high ambient light and water clarity, although they require soft substrate for establishment (Mumford 2007). On the northwest side of Island County, the State’s Smith and Minor Island Aquatic Reserve, contains both the largest bull kelp (*Nereocystis* spp.) bed in the state, and one of the highest diversity of algal communities in Puget Sound. This area has been surveyed annually by Dr. Robert Waaland, and is known to as a "hot spot" of algal diversity. Additionally, various species of kelp are known to be harvested for food in this location under WDFW seaweed harvesting licenses. (Lowell Dickson, DNR, personal communication, January 23, 2014).

Additional floating kelp beds at Possession Point, Scatchet Head and Double Bluff in Admiralty Inlet are extensive. Washington DNR has just completed our draft Marine Vegetation Atlas http://www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_nrshr_mva.aspx with historic kelp documentation from 9 different studies representing time frames from the 1800's to present. This data is not yet available as a data download, but DNR may be contacted to provide the most recent data. (Lowell Dickson, DNR, personal communication, January 23, 2014). Aquatic reserve mapping, including the kelp beds around the Smith and Minor Island, are included on Map 1.

As a result of the high biological diversity, important biological and physiochemical processes, and vulnerable habitats and species, this area was the top ranked site in the East Strait of Juan de Fuca region identified in DNR's Priority Marine Sites for Conservation in the Puget Sound (WDNR 2010).

Pocket estuaries

Although not specifically identified as a habitat of local importance, pocket estuaries, small estuarine habitats typical of Island County estuaries, provide a significant habitat for federally threatened salmonids and non-listed anadromous salmonids. Per WAC 365-190-080, counties and cities must give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries. The location of Island County at the junction of Puget Sound, the Strait of Juan de Fuca, and Georgia Strait, means that most Puget Sound juvenile and adult salmon and trout populations use or pass through the marine waters surround Island County (SRP 2005).

Non-natal salmonid use of pocket estuaries on Whidbey Island has been identified as an important factor contributing to salmonid production and population resilience (Beamer et al. 2005). Salmonid fry migrants preferentially use pocket estuary habitats compared to adjacent nearshore habitats, and this is particularly true for federally threatened juvenile Chinook salmon early in the spring outmigratory period (Beamer et al. 2003, Beamer et al. 2006a). Salmonids are believed to benefit from estuarine rearing through refuge from predation and an abundant source of invertebrate prey (Beamer et al. 2003). Salmonid use of the following currently accessible pocket estuaries in Island County have been studied and confirmed and are shown on Map 6.

- Grasser's Lagoon, Whidbey Island (Beamer et al 2006a)
- Elger Bay, Camano Island (Beamer et al. 2006a, Kagley et al. 2007)
- Arrowhead Lagoon, Camano Island (Beamer et al. 2006a)
- Triangle Cove, Camano Island (Beamer et al. 2006a)
- Ala Spit, Whidbey Island (Beamer 2007)
- Harrington Lagoon, Whidbey Island (Beamer et al. 2006b)
- Race Lagoon, Whidbey Island (Henderson et al. 2007)

For the above listed sites, salmonid densities were generally higher within the pocket estuaries than at adjacent nearshore sites; however, sampling in Dugualla Heights Lagoon, a pocket estuary separated from Puget Sound by a 30-inch-wide, 280-foot-long concrete culvert, did not capture any juvenile salmonids even though juvenile salmon were captured in the adjacent nearshore area (Beamer et al. 2012). At this site, the culvert appears to be a barrier to juvenile salmonids that prevents access to suitable rearing habitat.

Pocket estuaries in Island County also support diverse fish species other than salmon, including forage fish, shiner perch, threespine stickleback, staghorn sculpin, starry flounder, and arrow goby (Beamer et al. 2007, Henderson et al. 2007, Kagley et al. 2007). The majority of historical pocket estuary habitat in Island County and North Puget Sound has been lost McBride and Beamer 2010, Fresh et al. 2011, Schlenger et al. 2011, Simenstad et al. 2011), either as a result of direct filling, or draining or construction of dikes or tide gates that eliminate limit or eliminate tidal connectivity (WSCC 2000). Conservation of habitat quality and connectivity of these remaining habitats is of particular importance. In 2001, an estuarine restoration plan was prepared for Island County Public Works (Fischer and Harper 2001). The plan identified recommendations for preliminary actions and necessary studies for 17 estuaries in Island County, twelve on Whidbey Island, and five on Camano Island. In addition to all of the pocket estuaries identified above, sites included Crescent Harbor, Swantown Lake, Kennedy Lagoon, Crockett Lake, Lake Hancock, Deer Lagoon, Maxwelton Estuary, and Cultus Bay on Whidbey Island, and Livingston Bay on Camano Island (Fischer and Harper 2001). Beamer et al. (2005) also identified pocket estuaries within the Whidbey Basin (Camano Island and east side of Whidbey Island). Many of these pocket estuaries are inaccessible to fish, and these areas represent potential restoration opportunities (Beamer et al. 2005, Figure 1).

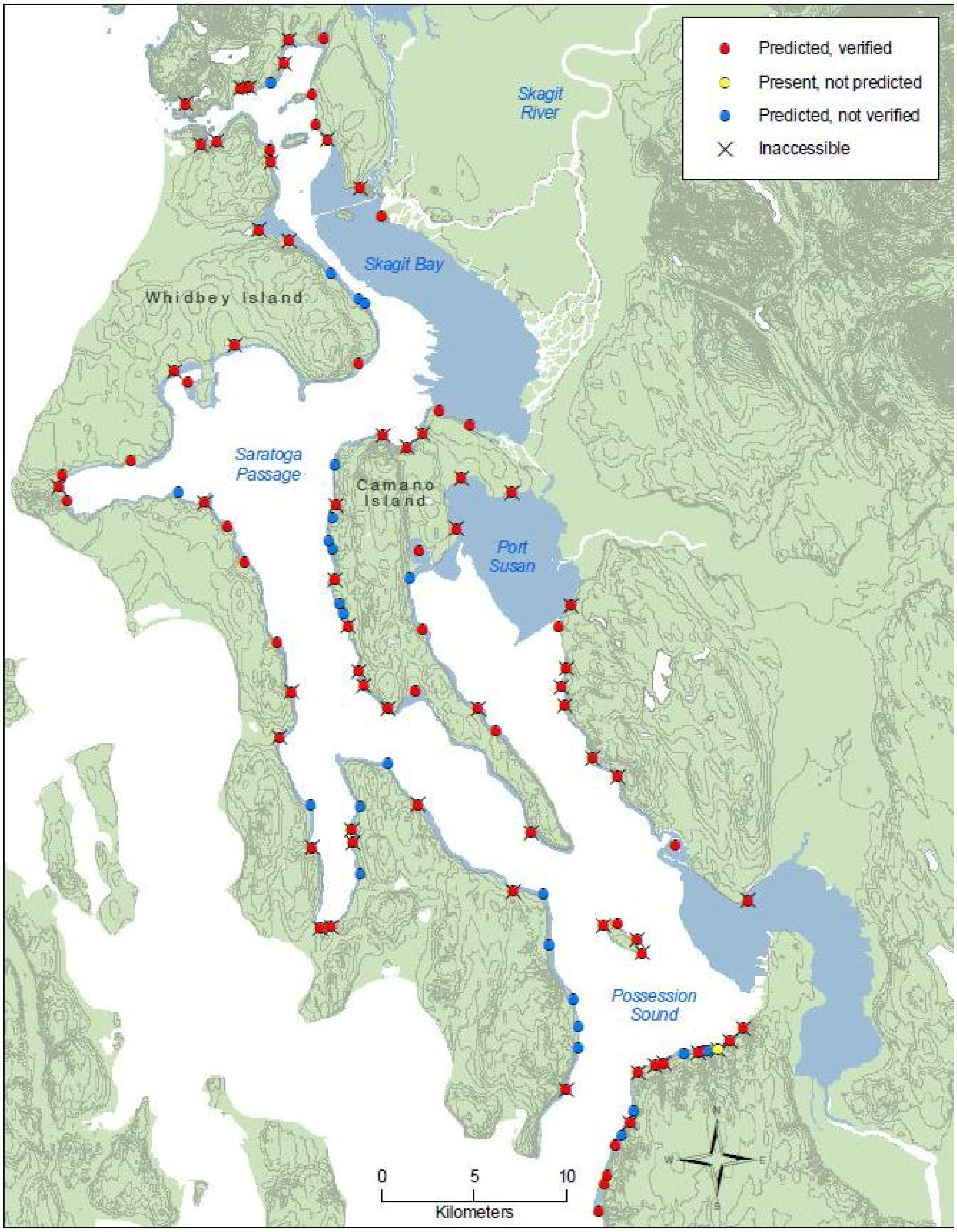

Figure 4. Map of pocket estuaries in the Whidbey Basin identified by a model in Beamer et al. 2005. Of the validated sample, 68% of the historically present pocket estuaries (58 sites) are no longer accessible for fish. From Beamer et al. 2005.

4 LANDSCAPE PROCESSES AND POTENTIAL EFFECTS OF DEVELOPMENT

The following discussion focuses mainly on impacts associated with residential development and public roads because of their predominance in Island County and because those are the impacts most relevant to critical areas regulations in the County.

4.1 Water Flow Processes

Water flow processes are defined by the delivery, movement, and loss of water within a watershed. Water flow processes are central to shaping aquatic habitat functions. These processes are shaped by precipitation, infiltration, floodplain and groundwater storage and transport, surface runoff, and instream flow. It is important to recognize how local habitat functions are influenced by physical form (structure), which is controlled by landscape-scale processes. For example, flow regimes can affect channel form (e.g., bank and bed erosion) which in turn influences how habitats are used by fish and wildlife. An understanding of how water flow processes affect fish and wildlife functions and how human alterations to the landscape affect water flow processes will allow a more complete understanding of the causes behind altered or degraded habitat form and functions, as well as possible approaches to addressing degraded functions effectively.

Hydrologic source areas occur where runoff converges and groundwater rises to form surface water drainageways (Qiu 2003, 2009). These source areas are particularly significant in controlling downstream hydrology, sediment transport, and ecological functions. These small stream channels typically represent the most stream miles in the watershed, and as a result of their low volume, they have more channel edge compared to larger streams (FEMAT 1993, Knutson and Naef 1997). Disturbance of these headwater source areas may have disproportionate effects on water flow processes throughout a watershed. In Island County, many of these hydrologic source areas have already been altered, and may occur across the landscape as intermittent agricultural ditches, drainage swales through developed properties, or degraded wetlands.

Freshwater flow regimes can influence estuarine communities by altering the influx of freshwater and corresponding salinities, particularly in small estuarine channels (Buzzelli et al. 2007). Tidal wetlands that are fed by freshwater seeps or streams provide localized freshwater input and support species that include native shellfish and shorebirds (Schlenger et al. 2011). Freshwater seeps along Puget Sound beaches also maintain cooler substrate temperatures that support successful incubation of forage fish embryos (Penttila 2001). Many sedentary or sessile estuarine species are adapted to a range of salinities, and may not tolerate frequent pulses in freshwater (Chew and Ma 1987 in Dethier 2006). Therefore, alterations to natural flow regimes may alter the size, location, and/or composition of estuarine species assemblages.

Land cover has a significant effect on water flow through the watershed. Current land cover trends in the Puget Sound region are correlated with increased high flows, increased variability in daily streamflow, reduced groundwater recharge, and reduced summer low flow conditions (Burges et al. 1998, Jones 2000, Konrad and Booth 2005, Cuo et al. 2009). Changes in hydrology related to development are generally associated with soil compaction, draining, and ditching across the landscape, increased impervious surface cover, and decreased forest cover (Booth and Jackson 1997, Moore and Wondzell 2005). Together, these changes reduce infiltration, evapotranspiration, and groundwater storage, and they increase surface flows.

Hydrologic changes from development are expected to be most significant in small- to intermediate-sized streams with naturally low seasonal and storm flow variability (Konrad and Booth 2005), which are characteristic of most stream systems in Island County. A model of potential development scenarios for Crescent Creek on Whidbey Island concluded that an increase in impervious surfaces from 7.5 to 11.25 percent would increase average peak flows by an average of 10 percent (Mickelson 2009). This study exemplifies how an increase in development, even at relatively low densities, along a small drainage can disproportionately affect water flow processes. In addition to effects on streams, development at the top of bluffs can accelerate natural bluff erosion by saturating soils (Shipman 2001, 2004). Potential effects of this change are addressed further in Section 5.

In Island County, the effects of development on groundwater and surface water are a particular concern. Approximately 72 percent of the County’s residents rely on wells for water supply, and groundwater is recharged by infiltration of precipitation (Island County 2005). In addition to direct groundwater withdrawal, development can reduce groundwater by reducing infiltration and accelerating the transport of water downstream. Where streamflows are influenced by groundwater, a lowering in groundwater levels may lower or dry out streams or result in warmer stream flows (See section 4.6 for discussion of Stream Temperatures). Alternatively, ditch and drainage structures commonly associated with agriculture and roads accelerate drainage and limit infiltration, reducing groundwater storage. The impacts on streamflow from shallow wells have not been quantified. Where groundwater is depleted along the shoreline, there is the potential for saltwater intrusion to occur (Island County 2005). Future sea level rise may exacerbate potential saltwater intrusion. In addition to implications to access to drinking water supplies, high salinity groundwater could affect existing freshwater and estuarine habitats.

The altered hydrology that is associated with development alters the geomorphic condition of streams, as well as sediment and pollutant transport (Arnold and Gibbons 1996, Booth and Jackson 1997, Booth and Henshaw 2001). Konrad et al. (2005) suggest that streams in urbanized watersheds may lack the longer duration high flows necessary to maintain stable channel conditions because development tends to result in shorter duration and more frequent high flow conditions. Changes in a stream's hydrograph associated with increased impervious surface coverage and decreased forest cover have been linked to decreased bank stability and increased erosion (May et al. 1997, Booth et al. 2002). In King County, Washington, stream instability was noted in watersheds with both rural (approximately 4 percent impervious surface coverage) and urban (over 10 percent effective impervious surface coverage) development densities, and the extent of instability was dependent on the percentage of forest cover retained (Booth et al. 2002, Figure 1). Based on the findings of Booth et al (2002), in rural areas where less than 60 percent of forest cover is retained, unstable channels may occur, and if forest retention is less than 40 percent, unstable channels are expected to occur (Booth et al., Figure 1). This finding is significant for Island County, where approximately 93 percent of the County is zoned for rural residential uses (SRP 2005). Recent forest conversions rates in the County were significantly higher than nearby watersheds (Shattuck and Marks 2009). Rural residential development at a density of 1 dwelling unit per 2.5 acres is expected to have an effective impervious surface area of 4 percent (Dinicola 1989 *in* Booth et al. 2002). Therefore, zoning densities in Island County, which predominantly have maximum densities of 1 dwelling unit per 5 acres, may help minimize effects on water flow processes resulting from impervious surface area.

However, even in these rural areas, the rate of forest loss in Island County is a concern because at a forest conversion rate of 0.15 percent per year, the proportion of forest conversions relative to existing forest area in Island County (WRIA 6) was approximately three times higher than in WRIA 5 (Stillaguamish), and two times higher than in WIRA 7 (Snohomish) in the years from 2005 to 2008 (Shattuck and Marks 2009).

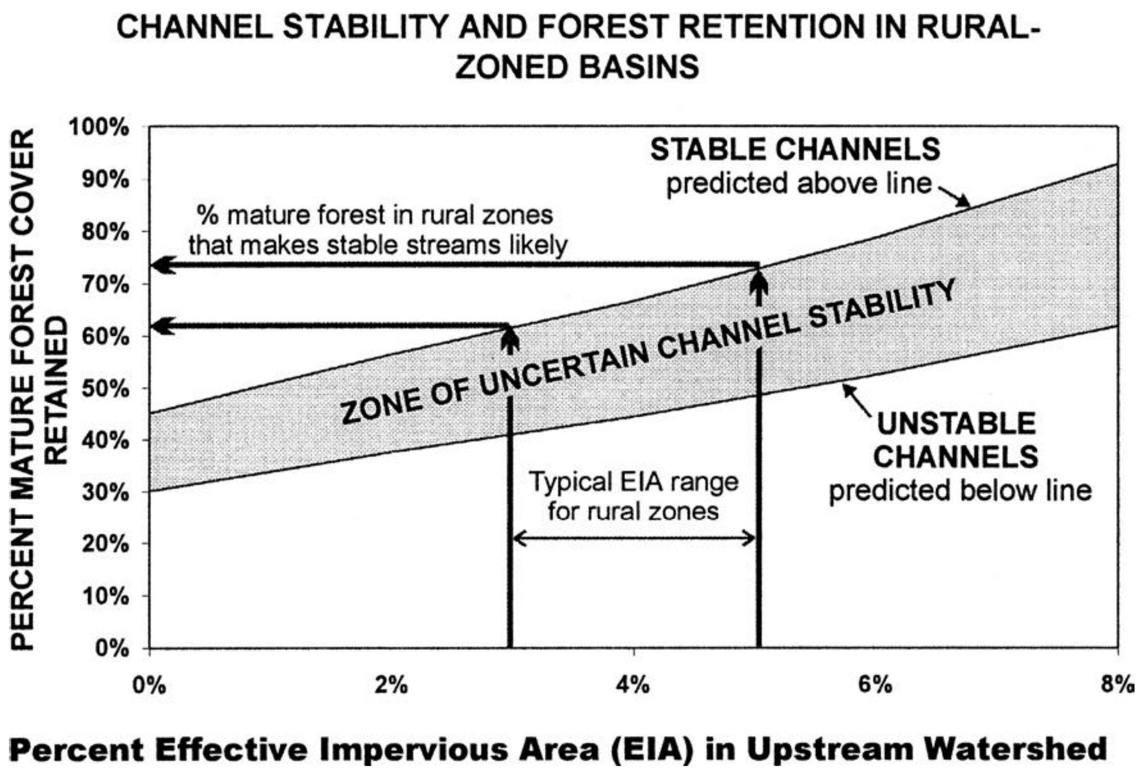

Figure 5. Generalized diagram showing the relationship between impervious surface area, forest cover, and channel stability in rural basins (from Booth et al. 2002).

Increased erosion and bank instability associated with development and reduction of forest cover often simplifies stream morphology, leading to incised, wider, straighter stream channels (Arnold and Gibbons 1996, Booth and Jackson 1997, Booth 1998, Konrad et al 2005). In turn, simplified stream channels, including ditched channels, accelerate water transport and reduce temporary instream flood storage capacity (Kaufmann and Faustini 2012), thereby exacerbating flooding downstream and reducing infiltration potential. Once physical drainages are manifested, a stream may not regain its channel form even after the runoff has been reduced (Montgomery and Dietrich 1992).

As noted above, watershed land cover characteristics have a significant effect on water flow processes. Whereas watershed-scale conditions are clearly significant for determining flow conditions, investigations of the role of hydrologic source areas and development alternatives that help maintain natural hydrologic conditions reveal some opportunities for more site-specific management of water flow processes. Protection of the headwaters of streams and wetlands may be one of the most effective means of protecting hydrologic processes, as well as water quality conditions. Qiu et al. (2003, 2009) and Tomer et al. (2009) modeled the effects of protecting these hydrologic source areas related to water quality. Because increased surface water flows are responsible for the increased transport of pollutants, they found that buffers were most effective in maintaining water quality conditions in watersheds where these hydrologic source areas were protected in riparian buffers.

The implementation of low impact development (LID) approaches, including clustered development, pervious pavement, bioretention swales, and vegetation retention, can significantly limit the effects of development on hydrologic regime. An 8.27-acre LID case study in South Puget Sound produced surface and shallow sub-surface runoff rates consistent with average runoff under forested conditions (Hinman 2009). To the extent that these sorts of projects are implemented in a watershed, effects of development on water flow processes may be minimized.

4.2 Water Quality

When development results in reduced infiltration and increased surface flows, sediment and contaminants are transported more directly to receiving bodies, avoiding natural soil filtration processes. The water quality factors specifically addressed in the Puget Sound Watershed Characterization (Stanley et al. 2012) include fine sediment, metals, pathogens, and nutrients. Although not specifically addressed in the Watershed Characterization, artificially-fabricated chemicals, including pesticides, herbicides, and pharmaceuticals also have the potential to significantly degrade aquatic resources and habitats. Each of these factors will be addressed in the following sections.

Island County has had a comprehensive Water Quality Monitoring Program in place since 2006. The goal of the monitoring program is to ensure that Island County's valuable resources such as swim beaches, shellfish beds, and anadromous fish streams and nearshore habitats are protected from degradation caused by water pollution (Island County Surface Water Monitoring Program, 2007 – 2011, Island County Environmental Health, in preparation, 2013).

Monitoring during 2007 – 2011 was organized into three categories – Baseline Monitoring (within 24 watersheds, 12 on Whidbey Island and 12 on Camano Island), Reconnaissance monitoring (43 sites to determine areas of future focus), and Source Identification monitoring (10 watersheds out of which two, South Holmes Harbor and Rocky Point on Camano Island continue additional monitoring). Water Quality Monitoring results for fecal coliform, nitrates, and phosphates are discussed by section below.

4.3 Sediment

Sediment input to streams is supplied by bank erosion, landslides, and upland erosion processes. Excess inputs of fine sediments into a stream channel reduce habitat quality for fish, amphibians, and macroinvertebrates. Fine sediment adversely affects stream habitat by filling pools, embedding gravels, reducing gravel permeability and increasing turbidity. In salmon-bearing streams, fine sediment fills interstitial spaces in redds, reducing the flow of oxygenated water to developing embryos and reducing egg-to-fry survival (Jensen et al. 2009). Higher levels of fine sediment are also correlated with lower salmonid growth rates (Suttle et al. 2004). Highly turbid water can impair fertilization success in spawning salmonids (Galbraith et al. 2006) and interfere with the respiration and reproduction amphibians (Knutson et al. 2004). When excess fine sediment is transported to estuarine areas, it can smother filter feeders, including native clams and other macroinvertebrates, and fine sediment may impair larval settlement of macroinvertebrates (Dethier 2006). High turbidity resulting from upland runoff can limit light levels necessary for growth and survival of eelgrass and kelp (Mumford 2007). Sedimentation can also prevent kelp spores from attaching to shoreline substrate needed for establishment (Schiel et al. 2006). Other contaminants, including heavy metals and phosphorus, readily bind to suspended clay particles, and these contaminants are often transported with fine sediment in stormwater.

Upland clearing and grading can result in long-term increases in fine sediment inputs to streams (Gomi et al. 2005, Jackson et al. 2007). Additionally, as noted in Section 3.1, because of the increased channelization of surface water flows in more urbanized areas, conversions of undisturbed vegetated lands to urban areas resulted in a disproportionate amount of sediment and contaminants to receiving waters relative to the percentage of urbanized area within the watershed (Sorrano et al. 1996). Another watershed-scale model found that agricultural land use generated the greatest influx of sediment, followed by urban land use (Allan et al. 1997). In Island County, agriculture may contribute to fine sediment loading through regular soil-disturbing activities (e.g., tilling). No research was identified on the effects of periodic dredging of agricultural channels on sediment transport; however, dredging may reduce the total fine sediment loading, but may also result in a pulse of mobilized fine sediment to downstream habitats.

Vegetated riparian zones are common management tools to help stabilize stream banks and slow and filter overland flow, and temporarily store sediment that is gradually released to a stream. Sediment filtration is also high within intermittent and ephemeral streams, presumably because of the high interface with vegetative structures and the flux in water surface elevation, which allows for sediment storage along the streambanks (Dietrich and Anderson 1998). Where small channels have been ditched or channelized to accelerate drainage, the residence time within these small channels may be reduced, limiting potential sediment retention. To the extent that these channels incorporate inset floodplains, sediment retention may be higher.

Numerous studies have investigated the effectiveness of varying widths of buffers at filtering sediment. These studies have typically found high sediment filtration rates in relatively narrow buffer areas (Sheridan et al. 1999, Wenger 1999, Parkyn 2004, Yuan et al. 2009). For example, a field plot experimental study of vegetated filter strip effectiveness found sediment retention of 68 percent in a 2-meter-wide filter strip, and 98 percent in a 15-meter-wide filter strip (Abu-Zreigh et al. 2004). The same study did not find a significant improvement in sediment retention beyond 15 meters.

It is significant to note, however, that field plot experiments tend to have much shorter field lengths (hillslope length contributing to drainage) than would be encountered in real-world scenarios (*i.e.*, ~5:1 ratio of field length to riparian width for a field plot compared to 70:1 ratio in NRCS guidelines). Since water velocities tend to increase with field length, field plot experiments may suggest better filtration than would be encountered under real-world conditions. Additionally, field-scale experiments generally do not account for flow convergence, which reduces sediment retention (Helmers et al. 2005) or for stormwater components that bypass filter strips through ditches, stormwater infrastructure, and roads (Verstraeten et al. 2006). Therefore, the effectiveness of filter strips at filtering sediment under real-world conditions and at the catchment scale is likely to be lower than what is reported in field plot experiments.

Additionally, many studies on sediment retention in riparian zones consider sediment retention from one storm event, rather than accounting for sediment accumulation over time. Two studies used Cesium-137 to track the location of sediment deposition over many years. One of these studies considered the distance that sediment traveled across a riparian forest adjacent to cropland with sandy loam soils and a mean hillslope of 2-5% (Lowrance et al. 1988 in Wenger 1999). The greatest amount of sediment was deposited 30 m (98 ft) into the forest and the strongest signal of Cs-137, which has a high affinity for fine clay particles, was found 80 m (262 ft) into the forest). Therefore, fine sediments can become transported through riparian areas for long distances. The other study found that over 50% of sediment was transported over 100 m (328 ft) into the riparian zone, over hillslopes ranging from 0 % to 20% (Cooper et al. 1988 in Wenger 1999). Together these studies suggest that riparian zones from 30-100 m (98-328 ft) or more may be necessary to provide long-term sediment retention, and that studies of short-term sediment retention underestimate the riparian zone width needed for ongoing sediment filtration.

In addition to width, the slope, vegetation density, and sediment composition of a riparian area have significant bearing on sediment filtration potential (Jin and Romkens 2001). A recent model of sediment retention in riparian zones found that a grass riparian zone as small as 4 m (13 ft) could trap up to 100% of sediment under specific conditions (2% hillslope over fine sandy loam soil), whereas a 30 m (98 ft) grass riparian zone would retain less than 30% of sediment over silty clay loam soil on a 10% hillslope (Dosskey et al. 2008, Figure 4). This study exemplifies the effects that soil type and hillslope have on sediment retention.

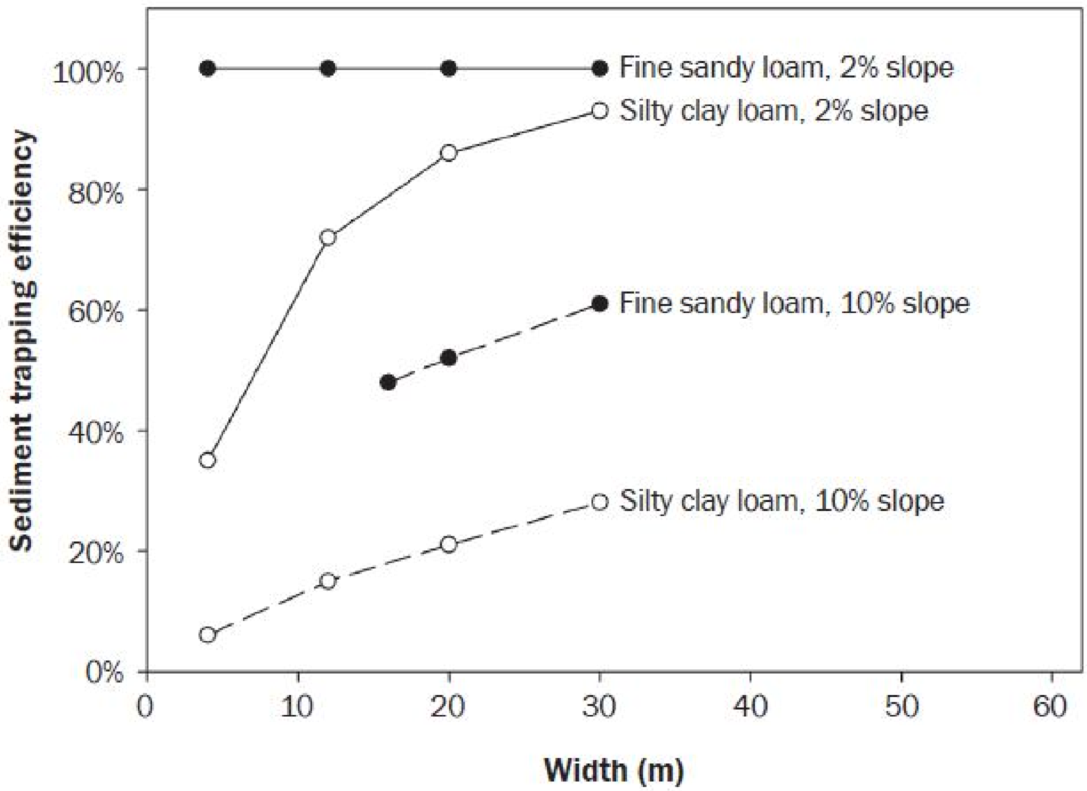

Figure 6. Sediment trapping efficiency related to soil type, slope, and buffer width. (Figure from Dosskey et al. 2008).

Multiple studies have found that larger particles tend to settle out within the first 3-6 m (10-20 ft) of the riparian zone, but finer particles that tend to degrade instream habitat, such as silt and clay, need a larger riparian zone, ranging from 15-120 m (49-394 ft), for significant retention (reviewed in Parkyn 2004). Lee et al. (2003) found higher sediment retention rates (92% and 97% respectively) in a 7 m (23 ft)grass riparian zone and a 16 m (52 ft) grass/forested riparian zone (5% slope, fine clay loam soil) than would be predicted by the Dosskey et al. study. However, the concentration of fine particles was greater leaving the riparian zone than entering it, indicating that larger particles settled out, while fine particles passed through the riparian zone (Lee et al. 2003).

Vegetative composition within the buffer also affects sediment retention. Vegetation tends to become more effective at sediment and nutrient filtration several years after establishment (Dosskey et al. 2007). Dosskey et al. (2007) did not find a significant difference between the filtration effectiveness of established grass and forested buffers. However, a meta-analysis of 81 buffer studies indicated that all-grass and all-forest buffers tend to more effectively filter sediment compared to buffers with a mix of grass and forested vegetation (Zhang et al. 2010). Additionally, whereas thin-stemmed grasses may become overwhelmed by overland flow, dense, rigid-stemmed vegetation provides improved sediment filtration that is expected to continue to function better over successive storm events (Blanco-Canqui et al. 2004, Yuan et al. 2009).

4.4 Metals, Pathogens, and Synthetic Contaminants

Heavy metals, bacterial pathogens, as well as PCBs, hydrocarbons and endocrine-disrupting chemicals are aquatic contaminants that are commonly associated with urban and agricultural land uses. The following sections summarize our understanding of the effects of metals, pathogens, and other chemical contaminants and how we might manage those effects for fish and wildlife.

The full suite of sublethal and indirect effects of these contaminants and combinations of contaminants on aquatic organisms is not fully understood (Fleeger et al. 2003). Some contaminants with potentially severe repercussions for fish and wildlife have yet to be identified. For example, recent research in the Puget Sound region has identified mature coho salmon that return to creeks and die prior to spawning, a condition called pre-spawn mortality (Feist et al. 2011, Sholz et al. 2011). The specific cause of the condition has not yet been identified; however, the condition is linked to urbanized watersheds and is positively correlated with the relative proportion of roads, impervious surfaces, and commercial land cover within a basin (Feist et al. 2011). A model of the effects of pre-spawn mortality on coho salmon populations indicates that, depending on future rates of urbanization, localized extinction of coho salmon populations could occur within a matter of years to decades (Spromberg and Scholz 2001). This finding emphasizes the significance of efforts to address both point-source and non-point-sources of contaminants in the landscape.

Metals

Although all metals can be toxic at high concentrations, cadmium, mercury, copper, zinc, and lead are particularly toxic even at low concentrations. Chronic and acute exposure to heavy metals have been found to impair, injure, and kill to aquatic plants, invertebrates, fish, particularly salmonids, and seabirds (Alexander 1991, Grant and Ross 2002, ESV Environment Consultants 2003, Burgess and Hobson 2006, Dethier 2006, Hecht et al. 2007, Burgess and Meyer 2008, McIntyre et al. 2008). Mercury levels bioaccumulate, resulting in higher tissue concentrations and potential effects on species at higher trophic levels (Burgess and Hobson 2006, Burgess and Meyer 2008). A review of contaminant effects on aquatic organisms summarized the factors affecting the toxicity of metals as follows:

- Duration and concentration of exposure
- The form of the metal at the time of exposure
- Synergistic, additive or antagonistic interactions of co-occurring contaminants
- Species sensitivity
- Life stage
- Physiological ability to detoxify and/or excrete the metal and,
- The condition of the exposed organism (ESV Environment Consultants 2003).

Metals are typically transported to the aquatic environment through fossil fuel combustion, industrial emissions, municipal wastewater discharge, and surface runoff (ESV Environment Consultants 2003). Management considerations to limit the transport of metals to aquatic areas include low impact development (LID), municipal stormwater treatment, and keeping roads and other pollutant sources away from watercourses.

Pathogens

Waterborne pathogens associated with human and animal wastes are a primary concern for commercial and recreational shellfish harvests and shellfish consumption in the Puget Sound. Although pathogens include a suite of bacteria and viruses, fecal coliform bacteria is typically used as an indicator of the presence of these pathogens. Fecal pollution tends to be positively correlated with human population densities and impervious surface coverage (Glasoe and Christy 2004). The main sources of fecal pollutants include municipal sewage systems, on-site sewage systems, stormwater runoff, marinas and boaters, farm animals, pets, and wildlife (Glasoe and Christy 2004). Although not necessarily representative of Island County, a study in Australia found that concentrations of *E. coli* bacteria in streams was predicted by the density and proximity of septic systems relative to natural drainages (Walsh and Kunapo 2009). This finding is relevant to Island County, where approximately 72 percent of residents use on-site septic systems (Island County, electronic reference). As municipal wastewater systems have improved treatment quality and capacity in recent years, increasingly, non-point source (septic systems, stormwater, and pets) pollution is responsible for shellfish closures in Puget Sound (Glasoe and Christy 2004, Dethier 2006). As a result, recommendations for reducing bacterial loads include sewage management, surface water management, public education, and better handling of marina and boater wastes (Glasoe and Christy 2004).

Island County's Water Quality Monitoring Program collected baseline data on nitrates, phosphates, and fecal coliform bacteria for 2007 through 2011. The results are shown in Map 8. The map also shows the location of shellfish beds, streams, and kelp and eelgrass beds within the marine nearshore.

Map 8 shows the results for fecal coliform monitoring from 2007 to 2011. Generally, natural areas met fecal coliform water quality standards, while those standards were exceeded in both agricultural and developed areas. Thirteen of the twenty-two monitored watersheds exceeded fecal coliform standards during three or more of the five year monitoring period (Island County Public Health, 2013). Ebey's Landing had the highest level of degradation due to fecal coliform. While Rocky Point exceeded standards, work by the Water Quality Point Source identification program funded by a Department of Ecology grant resulted in identification of the problem, and through outreach by the Water Quality program, a significant reduction in fecal loading within this watershed has occurred since 2007 and 2008 source identification sampling.

Based on results from 2007 to 2011, the Island County Water Quality Monitoring Program is in the process of building on this data, and refining future monitoring efforts. Fourteen priority watersheds have been identified on which to focus future monitoring efforts. The focus of these watersheds is a combination of the presence of valuable natural resources, such as salmon streams, shellfish beds, or swim beaches, in combination with fecal coliform exceedances. In addition, the Water Quality Program continues grant funded projects related to improving water quality and human health in Maxwelton Creek, a salmon-bearing stream that currently drains to the nearshore with a shellfish bed currently closed to harvest. Additional focused source tracking work is scheduled to occur in South Holmes Harbor and Cultus Bay. (Island County Environmental Health, in preparation, 2013).

Herbicides and Pesticides

Commonly used herbicides and pesticides may also affect aquatic communities, and the acute and chronic effects of these chemicals or combinations of chemicals are not always well understood. Additionally, effects documented in the laboratory may differ significantly from effects identified in a field setting (Relyea 2005, Thompson et al. 2004). Despite our limited understanding, the effects of these chemicals may be long-lasting, as has been observed for legacy pesticides such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in salmon, seabirds, and marine mammals in the Puget Sound (Calambokidis et al. 1984, O'Neill et al. 1998, Ross et al. 2000, Grant and Ross 2002).

Herbicides and pesticides may reach aquatic systems through a number of pathways, including surface runoff, erosion, subsurface drains, groundwater leaching, and spray drift. Narrow hedgerows have been found to limit 82-97 percent of the aerial drift of pesticides adjacent to a stream (Lazzaro et al. 2008). In runoff, herbicide retention in a buffer is dependent on the percentage of runoff that infiltrates the soil (Misra et al. 1996). A study of herbicides in simulated runoff found that 6-meter-wide vegetated buffers were sufficient to reduce herbicide concentration exiting the buffer to zero (Otto et al. 2008). A meta-analysis found that filtration effectiveness increased logarithmically from 0.5 m (1.6 ft) to an asymptote at approximately 18 m (59 ft) (Zhang et al. 2010). In summary, relatively narrow vegetated buffers may be effective in limiting herbicides and pesticides from reaching aquatic habitats in surface runoff, erosion, and spray drift; however, transport via subsurface drainage and leaching are not affected by riparian buffers, and these processes are best managed through the use of best management practices in herbicide and pesticide applications to avoid contaminating groundwater (Reichenberger et al. 2007).

Pharmaceuticals

Pharmaceuticals are another class of contaminants, the effects of which remain poorly understood. Many commonly used pharmaceuticals are found in wastewater and a few pharmaceutical components are detectable in marine sediments in the Puget Sound, particularly around more urban areas (Long et al. 2013). Many common pharmaceuticals have endocrine-disrupting properties, which can affect fertility and development in non-target aquatic species (Caliman and Gavrilescu 2009). The existing and potential population-scale effects of these chemicals in the environment are not yet well-understood (Mills and Chichester 2005, Caliman and Gavrilescu 2009). Measures to effectively manage impacts of pharmaceuticals involve proper disposal by the user and wastewater management. A study of the effectiveness of on-site sewage treatment at removing organic wastewater contaminants (OWCs) found that concentrations of OWCs in conventional septic systems were comparable to those measured in previous studies of municipal wastewater treatment plant (WWTP) *influent* (Wilcox et al. 2009). However, concentrations of OWCs in septic effluent were significantly lower from septic systems with advanced treatment using sand filtration or aerobic treatment, with concentrations similar to WWTP *effluent* (Wilcox et al. 2009).

4.5 Nutrients

In excess concentrations, nitrogen and phosphorus can lead to poor water quality conditions, including reduced dissolved oxygen rates, increased pH, and eutrophication (Mayer et al. 2005, Mayer et al. 2007). Excessive amounts of nitrogen and phosphorus speed up eutrophication and algal blooms in receiving waters, which can deplete the dissolved oxygen in the water and result in poor water quality and fish kills (Mayer et al. 2005, Dethier 2006, Heisler et al. 2008). More frequent occurrences of toxic algal blooms, such as those that cause Paralytic Shellfish Poisoning, are linked to increased eutrophication (Anderson et al. 2002). Also, nitrogen loading can reduce light transmittance by triggering algal blooms and growth of seagrass epiphytes, resulting in a reduction in the size of eelgrass and kelp beds (Steneck et al. 2002, Hauxwell et al. 2007, Mumford 2007). A reduction of eelgrass bed areas in bays in nearby San Juan County has prompted questions regarding effects of upland development (Wyllie-Echeverria et al. 2003).

Nutrients enter waterways through channelized runoff, groundwater flow, and overland flow. Nitrogen loading is often associated with agricultural activities, whereas low density residential development has been found to result in nitrate levels comparable to a forested basin (Poor and McDonnell 2007). Agricultural drainage ditches may transport nutrients to downstream habitats and dredging of agricultural channels results in short-term increases in the transport of nitrogen, phosphorus, and herbicides, likely because of a reduction adsorption potential (Smith et al. 2006, Smith et al. n.d.). This finding implies that dredging is best conducted when seasonal conditions and projected farm management activities are expected to have limited nutrient efflux (e.g., dry periods and periods when lands are not tilled or fertilized).

Headwater streams play an important role in denitrification as a result of the high surface area to volume ratio of sediment and biofilms to streamflow

(Peterson et al. 2001). In fact, headwaters are responsible for over 40 percent of the nitrogen flux in fourth order and larger streams (Alexander et al. 2007).

Map 9 shows the results of nitrate monitoring within Island County from 2007 to 2011. Nitrate levels are variable across the County. The highest level of nitrate pollution was found at Ebey's Landing. (Island County Environmental Health, 2013, internal draft).

Nitrogen removal in the riparian zone is recognized as one of the most cost-effective means to control excess nitrogen losses from intensively developed watersheds (Hill 1996). Riparian zones can reduce nitrogen pollution through nutrient uptake, assimilation by vegetation, and through denitrification (Sobota et al. 2012). The rate of nitrogen removal from runoff varies considerably depending on local conditions, including soil composition, surface versus subsurface flow, riparian zone width, riparian composition, and climate factors (Mayer et al. 2005, Bernal et al. 2007, Mayer et al. 2007). Nutrient assimilation is also dependent on the location of vegetation relative to the nitrogen source, the flowpath of surface runoff, and position in the landscape (Baker et al. 2006). As a result of this variability, a meta-analysis of studies of nutrient removal in riparian buffers ranging from 1-200 m (3-656 ft) concluded that buffers wider than 50 m (164 ft) remove nitrogen more effectively than buffers less than 25 m (82 ft) wide; however, within the categories of 0-25 m (0-82 ft), 25-50 m (82-164 ft), and >50 m (164 ft), factors other than buffer width determine nitrogen removal effectiveness (Mayer et al. 2007). Riparian zones less than 15 m (49 ft) actually contributed to nitrogen loading in some cases (Mayer et al. 2007). Another meta-analysis of nutrient removal studied buffers up to 22 m (72 ft) wide, and found that these buffers effectively removed 92 and 89.5 percent of nitrogen and phosphorus, respectively (Zhang et al. 2010)

Mayer et al. (2005, 2007) found that riparian zones ranging from 1-200 m (3-656 ft) generally removed 89% of *subsurface* nitrates regardless of riparian zone width. On the other hand, nitrate retention from *surface* runoff was related to riparian zone width, where 50%, 75%, and 90% surface nitrate retention was achieved at widths of 27 m (88 ft), 81 m (266 ft), and 131 m (430 ft) respectively (Mayer et al. 2007). This suggests that surface water infiltration in the riparian zone should be a priority to promote effective nutrient filtration. Where soils are poorly drained and infiltration capacity is limited, the effectiveness of nutrient removal in riparian buffers may also be limited (Wigington et al 2003).

The composition of the riparian zone also affects the efficiency of nutrient removal. Reviews of buffer effectiveness have found that forested riparian zones remove nitrogen and phosphorus more efficiently than grass/forested riparian zones (Zhang et al. 2010). And Mayer et al. (2007) found that herbaceous buffers had the lowest effectiveness compared to forested wetland, forested, and forested/herbaceous buffers. Other studies have found conflicting results, indicating that grass buffers remove nitrogen and phosphorus as well or better than forested buffers (reviewed in Polyakov 2005). Where nitrogen-fixing species predominate, such as red alder, these buffers tend to have higher soil nitrate concentrations (Monohan 2004). These findings indicate that the nitrogen removal efficiency of buffers can vary depending on the size and species composition of the buffer.

Season can also play a significant role in denitrification, because denitrification rates are higher in saturated soil because of the anoxic conditions (Bernal et al. 2007). Given the seasonal climate patterns in Island County, denitrification rates are expected to be higher in winter compared to summer.

Map 10 shows the results of the orthophosphate monitoring from 2007 to 2011. Again, rates are variable across the county, with the highest level of degradation at Ebey's Landing. (Island County Environmental Health, 2013, internal draft).

Removal of phosphorus by riparian buffers is dependent on the form of phosphorus entering the buffer. Whereas phosphorus that is adsorbed by soil particles is effectively removed through sediment retention within a buffer, the retention of soluble phosphorus relies on infiltration and uptake by plants (Polyakov 2005). One long-term study found that phosphorus uptake was directly proportional to the plant biomass production and root area over the four-year study period (Kelly et al. 2007). If a riparian buffer becomes saturated with phosphorus, its capacity for soluble phosphorus removal will be more limited (Polyakov 2005). Another long-term study found that following a 15-year establishment period, a 40-meter-wide, three-zoned buffer reduced particulate phosphorus by 22 percent, but dissolved phosphorus exiting the buffer was 26 percent higher than the water entering the buffer, so the buffer resulted in no net effect on phosphorus (Newbold et al. 2010).

In summary, most riparian zones reduce subsurface nutrient loading, but extensive distances are needed to reduce nutrients in surface runoff. Filtration capacity decreases with increasing loads (Mayer et al. 2005), so best management practices across the landscape that reduce nutrient loading will improve riparian function.

5 FRESHWATER HABITATS AND POTENTIAL EFFECTS OF DEVELOPMENT

Freshwater habitat conditions are influenced by catchment land cover, longitudinal riparian and floodplain corridors, surficial geology, climate, as well as local area conditions. Research has explored how these different scales of influence relate to both physical and biological indicators of stream condition (e.g., Vannote et al. 1980, Swanson et al. 1988, Gregory et al. 1991, Naiman et al. 1992). An understanding of the relationship between land use and stream conditions at these different scales can inform multi-scalar land use management. The following discussions highlight the key components of freshwater habitats and how development impacts those habitats at the catchment, riparian, and local scales.

5.1 Headwaters

Because of the smaller size of the stream channel, riparian buffers may exert a greater influence on small, low-order streams compared to higher order streams (Vannote et al. 1980, Bilby and Ward 1989, Gregory et al. 1991). Riparian zones along small, low order streams have also been found to be more effective at reducing downstream temperatures compared to riparian buffers along larger channels (Brazier and Brown 1972, Cristea and Janisch 2007). Riparian areas associated with low-order streams produce significant quantities of litterfall (Gomi et al. 2002) and invertebrates (Wipfli and Gregovich 2002, Wipfli 2005, Wipfli et al. 2007) that are transported downstream to fish-bearing waters. In many cases, juvenile coho salmon and cutthroat trout have been found in small, intermittently flowing channels (e.g., Wigington et al. 2006, Colvin et al. 2009), and these channels should not be discounted as potential rearing habitats. Forested riparian areas associated with intermittent and headwater streams also provide sheltered humid environments for amphibian dispersal (Sheridan and Olson 2003, Olson et al. 2007, Welsch & Hodgson 2008), and amphibian densities are higher in those headwater streams with riparian buffers (Stoddard and Hayes 2005).

Longitudinal continuity of buffers along streams is an important factor determining the effectiveness of buffers at improving channel conditions. Riparian continuity is correlated with abundance and diversity of sensitive invertebrates (Wooster and DeBano 2006) and metrics of physical stream conditions (McBride and Booth 2005). On the other hand, fragmented riparian zones may not be sufficient to improve degraded instream habitat conditions. A study of fragmented riparian zones in New Zealand found that 12- and 17- acre forested plots at the downstream ends of 3rd order streams did not improve riffle depth, substrate size, stream temperatures, or sensitive invertebrate communities degraded by upstream agriculture lacking riparian zones (Harding et al. 2006). Harding et al. (2006) suggested that greater riparian continuity was needed to see notable improvement in instream conditions. Similarly, a watershed-scale study in Southwest Washington found that stream conditions were best maintained with continuous buffers, compared to patch buffers or no buffers (Bisson et al. 2013).

5.2 Physical Structure

The physical geomorphology of aquatic habitats is fundamentally shaped by the processes of water flow, sediment transport, and wood transport. As discussed in Section 3.1 (Water Flow Processes), development tends to increase the frequency of high flows and the variability in high flow events (Burges et al. 1998, Jones 2000, Konrad and Booth 2005, Cuo et al. 2009), which in turn results in deeper, wider, and straighter channel form (May et al. 1997, Booth et al. 2002). As identified above, habitat structure is closely related to function. For example, juvenile coho salmon selectively use pools with structural cover and off-channel areas for winter rearing (Bustard and Narver 1975, Tschaplinski and Hartman 1983). As noted in the WRIA 6 Limiting Factors Report (WCCC 2000), "streams with more structure (such as logs and undercut banks) support more coho salmon, not only because they provide more territories (useable habitat), but they also provide more food and cover." Furthermore, hydraulically complex streams lose proportionately fewer fish during floods and support more diverse fish communities when compared to simpler channels (Pearsons et al. 1992).

Many small channels in Island County have been ditched and rerouted to facilitate agricultural, road drainage or other development. Some of the channels of the larger stream systems within Island County, such as Maxwelton Creek, have also been ditched and rerouted to facilitate development. In addition to increasing the transport capacity while reducing the storage capacity and recharge associated with these streams, these changes greatly reduce channel structural diversity and low velocity habitat during high flow events. These changes have implications for both stream habitat conditions during both low flow and high flow periods. For example, in the Skagit River Watershed, Beechie et al. (1994) determined that diking, ditching, and dredging associated with agricultural and urban lands accounts for a 73 percent loss of summer pool habitat for coho salmon, and a 91 percent loss of off-channel winter habitat. Additionally, culverts limiting fish passage on small tributaries accounted for 13 and 6 percent reduction of the area of summer and winter coho salmon habitat, respectively (Beechie et al. 1994).

Despite degraded channel structure, a study in Oregon found substantial use of agricultural intermittent, ditched-streams by native fish, albeit primarily tolerant, habitat generalists (Colvin et al. 2009). Limited use of these agricultural streams was observed by juvenile cutthroat trout and Chinook salmon, and fish species richness was positively correlated with the percentage of the watershed covered by forest and negatively correlated with distance to perennial streams (Colvin et al. 2009). These results raise the possibility that the landscape position of agricultural ditched-channels may allow for salmonid use, particularly if physical channel conditions are improved.

In general, development is known to have detrimental effects on salmonids. Pess et al. (2002) found that wetland occurrence, local geology, stream gradient, and land use were significantly correlated with adult coho salmon abundance. While positive correlations were found between spawner abundance and forested areas, negative correlations were found between spawner abundance and areas converted to agriculture or urban development.

Natural disturbances (e.g., mass-wasting events, landslides, channel migration) lead to spatial heterogeneity and temporal variability, which, in intermediate frequencies create diverse habitat niches for aquatic and semi-aquatic species. These processes and the associated spatial and temporal diversity are significant to promote resilience for aquatic populations, including salmonids (Bisson et al. 2009). Land use can affect the frequency and intensity of disturbance events (Nakamura et al. 2000), either by making such events more common (e.g., by increasing the frequency and intensity of high flow events) or by limiting natural sediment recruitment events (e.g., by stabilizing streambanks). As the frequency and intensity of disturbances change, those processes that help to allow for species resilience may be impaired.

Recent research has investigated the correlation between development and physical stream attributes at multiple spatial scales (Wood-Smith and Buffington 1996, Allan et al. 1997, McBride and Booth 2005, Segura and Booth 2010). Measures of physical and biological stream integrity are influenced by both catchment scale and riparian-scale conditions (Allan et al. 1997). At a catchment scale, a reduction in forest cover is correlated with a reduction in the frequency of pools and reduced residual pool depth (Wood-Smith and Buffington 1996 Booth and Jackson 1997, Booth 1998, Konrad et al 2005, Segura and Booth 2010). One study found that degraded physical stream attributes were most closely correlated to urban land cover at the sub-watershed scale and in an area within 500 m (1,640 ft) of the site, as well as the proximity to the nearest road crossing (McBride and Booth 2005). The same study found that physical stream conditions improved after passing through 100 m (328 ft) wide forests or wetlands, particularly when these areas were located away from road crossings (McBride and Booth 2005). Another study found that the amount of urbanization in a watershed determines the extent to which local-scale riparian vegetation is effective in mediating channel form and processes (Segura and Booth 2010). Riparian zones had a greater influence on stream morphology, including density of large woody debris, pool frequency, and sediment storage, in watersheds with lower densities of development compared to more highly developed watersheds (Segura and Booth 2010). Therefore, channel simplification caused by watershed-scale hydrologic changes from urbanization may override local scale influences of riparian vegetation on channel-forming processes, but vegetated riparian zones may be effective in mediating the effects of more rural development in a watershed.

Riparian vegetation helps provide bank stabilization through a complex of tree roots, brush, and soil/rock. A study in British Columbia concluded that major bank erosion is 30 times more likely on stream bends with bare banks compared to vegetated banks, and that densely vegetated banks are the most effective at resisting erosion (Beeson and Doyle 1995). Woody vegetation tends to provide greater bank stability than herbaceous vegetation because woody vegetation has larger roots that extend deeper into the streambank (Wynn and Mostaghimi 2006). Another British Columbia study found that streamside trees stabilized the banks and prevented their collapse, helping to create overhanging banks and winter habitat for coho salmon (Tschaplinski and Hartman 1983). In contrast, two of three study-sections that had been clear-cut logged had unstable banks which collapsed during winter freshets (Tschaplinski and Hartman 1983).

5.3 Woody Debris

Woody debris plays a significant role in geomorphic functions such as directing stream flows to shape the channel form and influencing sediment storage, transport, and deposition rates (Harmon et al. 1986, Sedell et al. 1988, Bilby and Bisson 1998). The collection of large woody debris (LWD) and the subsequent entrapment of smaller branches, limbs, leaves and other material reduce flow conveyance in small streams and increase temporary flood storage (Dudley et al. 1998). By retaining smaller organic debris, LWD provides substrate for microbes and algae, and prey resources for macroinvertebrates (Bolton and Shellberg 2001).

Just as riparian areas have a more significant effect on smaller channels compared to larger channels (Vannote et al. 1980), the effects of LWD in small channels are particularly significant (Harmon et al. 1986). In small channels, LWD provides important structures in the stream, controlling rather than responding to hydrologic and sediment transport processes (Gurnell et al. 2002). For this reason, large wood is responsible for significant sediment storage in small channels (Nakamura and Swanson 1993, May and Gresswell 2003). Large wood that partially blocks flow can also help to encourage hyporheic flow (Poole and Berman 2001, Wondzell et al. 2009). The channel profile of low-order bedrock streams is often modified by LWD debris jams that trap cobble and sediment into short, low-gradient alluvial reaches punctuated by energy-dissipating LWD cascades (Keller and Swanson 1979, Montgomery et al. 1996). This pattern of energy dissipation results in less available energy for erosion of bed and banks (Swanson and Lienkaemper 1978). The effect of LWD removal in these streams is usually incision or channelization of the stream, accelerated transport of fine sediments, quicker stormflow routing, and decreases in biological productivity (Swanson et al. 1976). LWD provides stream roughness that can help limit channel incision and streambank failures (Booth 1990).

Large woody debris also plays an important role in forming complex in-water habitat structures that provide flow refugia, essential cover, and improved foraging conditions for fish. Fausch and Northcote (1992) found that streams containing large amounts of LWD supported populations of juvenile cutthroat and coho salmon five times greater than streams within the same river system that had been cleared of LWD. Roni and Quinn (2001) found that winter densities of coho salmon, steelhead, and cutthroat trout were higher in streams where LWD had been added.

Large woody debris can enter channels through individual trees falling into the stream, as well as through larger disturbances, such as landslides and fire (Bragg 2000). A comparison of 51 streams with varying channel form in mature forests of British Columbia found that of the approximately one-third of LWD pieces for which the source could be identified, tree mortality was the most common (65 percent) entry mechanism (Johnston 2011). Streambank erosion is a common method of wood recruitment in large alluvial channels (Murphy and Koski 1989), whereas in smaller, steeper channels, wood recruitment predominantly occurs through slope instability and windthrow (May and Gresswell 2003).

The probability of a tree entering the channel decreases as distance increases from the stream (McDade et al. 1990, Grizzel et al. 2000). Past research has found that most LWD originates within approximately 30 m (98 ft) of a watercourse (Murphy and Koski 1989, McDade et al. 1990, Van Sickle and Gregory 1990, Robison and Beschta 1990). In 90 percent of the 51 streams surveyed in British Columbia, 90 percent of the LWD at a site originated within 18 m (59 ft) of the channel. May and Gresswell (2003) found that wood was recruited from distances further from the stream channel in small, steep channels (80 percent from 50 m (164 ft) from the channel), compared to broad alluvial channels (80 percent from 30 m (98 ft) from the channel because of the significance of hillslope recruitment in narrow valleys. Trees beyond one site-potential-tree-height (SPTH) from a creek also influence LWD recruitment indirectly by knocking down other trees closer to the stream when they fall (Reid and Hilton 1998).

The likelihood of downstream transport of LWD is dependent on the length of wood relative to bankful width of the stream (Lienkaemper and Swanson 1987). Wood that is shorter than the average bankful width is transported more readily downstream compared to wood that is longer than the bankful width (Lienkaemper and Swanson 1987). Therefore, large wood is rarely transported downstream from small channels less than 5 m (16 ft) in width (May and Gresswell), which are characteristic of Island County streams.

Similar to large wood, beaver dams slow water, retain sediment, and create pools and off channel ponds used by rearing coho salmon (Naiman et al. 1988, Pollock et al. 2004). Beavers are native to Island County, as evidenced by Whidbey native peoples trading beaver skins to the early fur traders and beaver bones found in middens (R. Milner, personal communication with K. Swanson November 18, 2013). The removal of these structures throughout history has been linked to a significant reduction in coho salmon summer and winter rearing habitat in the nearby Stillaguamish River (Pollock et al. 2004).

5.4 Invertebrates and Detritus

Terrestrial and aquatic invertebrates serve an important role at the base of aquatic food webs. In streams in Southeast Alaska, aquatic and terrestrial invertebrates are consumed by coho salmon in approximately equal proportions (Allan et al. 2003). The magnitude of fluvial discharge also affects the scale of distribution of detritus from freshwater to estuarine ecosystems (Howe 2012).

Aquatic invertebrates are sensitive to water quality, flows, and habitat structure, and they are often considered as indicators of stream habitat conditions (Karr 1998, Utz et al. 2009). It should be noted that macroinvertebrates may respond differently to watershed and local-scale habitat conditions compared to other species, such as fish, and these differences may be related to differences in species mobility and scale of influence (Infante et al. 2009). Studies in the Pacific Northwest have found that the diversity and relative prevalence of aquatic invertebrates that are sensitive to water quality conditions is inversely related to urban land cover (Hachmoller et al. 1991, Morley and Karr 2002, Utz et al. 2009) and, to a lesser extent, to agricultural land cover (DeLong and Brusven 1998, Herlihy et al. 2005, Utz et al. 2009) and positively correlated with forest cover Zhang et al. 2009). Hydrologic changes associated with basin and subbasin development have been correlated to degraded indices of invertebrate community integrity (Booth et al. 2004, Alberti et al. 2007, DeGasperi et al. 2009). DeGasperi et al. (2009) proposed that the frequency and range of flood pulses may best explain the correlation between the hydrologic effects of urbanization and the observed degradation of invertebrate communities. Utz et al. (2009) reported that sensitive aquatic invertebrates were not present when impervious cover was in the range of 3 to 23 percent, and the sensitivity of invertebrates to impervious surface cover varied with hydrogeomorphic factors.

Although urbanization at a catchment scale is correlated with a reduction in sensitive invertebrate species, those urbanized catchments with intact riparian buffers along the longitudinal stream gradient maintain a higher proportion of sensitive species compared to those without vegetated riparian corridors (Miltner et al. 2004, Moore and Palmer 2005, Walsh et al. 2007, Shandas and Alberti 2009).

On the other hand, studies at the reach scale have found conflicting results as to whether conditions affect (e.g., Roy et al. 2003, Booth et al. 2004, Stephenson and Morin 2009) or do not affect (e.g., Walsh et al. 2007) invertebrate species composition. Two studies found seemingly paradoxical results where densities of aquatic and terrestrial invertebrates in a stream were higher in disturbed reaches versus undisturbed forested reaches (Roy et al. 2005, Progar and Moldenke 2009). Both studies, however, found that the biomass of invertebrates did not differ between to the control and treatment reaches. These results may be related to smaller, early colonizing individuals that are able to exploit disturbed areas. Roy et al. (2003) determined that although invertebrate metrics were correlated with catchment-scale urbanization, specific reach-scale factors such as sediment grain size, total suspended solids, turbidity, and nutrient loads more closely correlated with invertebrate indices. Together, these studies suggest that invertebrate communities are sensitive to land use changes at both the watershed, riparian, and reach-scales, and that riparian continuity is a significant factor to maintain high levels of biological integrity.

In some cases, the immediate effects of forest clearing have produced unexpected results relating to invertebrate composition. For example, where clearcuts leave significant quantities of woody slash in the stream, an associated increase in collector and shredder invertebrates occurs for years following harvest (Jackson et al. 2007). On the other hand, Kiffney et al. (2003) observed an increase in tolerant Chironomid invertebrates following logging with 0, 10 m (33 ft), and 30 m (98 ft) buffers. Kiffney et al. (2003) and Hoover et al. (2007) concluded that 10-meter-wide buffers were not sufficient to protect stream invertebrate communities from the effects of logging. Kiffney and Richardson (2003, 2004) concluded that buffers over 30 m (98 ft) in width are necessary to avoid disturbing invertebrate communities.

5.5 Water Temperature and Microclimate

Stream temperatures and riparian microclimate conditions are closely tied to each other. Factors influencing water temperature and microclimate include shade, orientation, relative humidity, ambient air temperature, wind, channel dimensions, groundwater, and overhead cover (Brown and Kryger 1970, Beschta et al. 1987, Osborne and Kovacic 1993, Brosofske et al. 1997, Moore et al. 2005).

Salmon and native freshwater fish require cool waters (55-68°F) for migrating, rearing, spawning, incubation, and emergence (USEPA 2003). Thermal tolerances differ by species; coho salmon prefer the coolest temperatures, whereas steelhead can tolerate higher temperatures. A literature review of temperature effects on juvenile salmonid growth found that optimal growth occurred in field studies when daily maximum temperatures were 61-73°F for steelhead, 61°F for Chinook salmon, and 59°F for coho salmon (Ecology 2002). Riparian microclimate affects many ecological processes and functions, including plant growth, decomposition, nutrient cycling, succession, productivity, migration and dispersal of flying insects, soil microbe activity, and fish and amphibian habitat (Brosofske et al. 1997). Amphibians have narrow thermal tolerances, and they are particularly influenced by changes in microclimate conditions (Bury 2008).

Several studies have documented significant increases in maximum stream temperatures associated with the removal of riparian vegetation (Beschta et al. 1987; Murray et al. 2000, Moore et al. 2005, Gomi et al. 2006). A comparative study of 40 small streams in the Olympic Peninsula found that mean daily maximum temperatures were 2.4°C higher in logged compared to unlogged watersheds, and that logged watersheds had greater diurnal fluctuations in water temperatures (Pollock et al. 2009).

A number of studies have considered the extent to which different riparian zone widths modulate stream temperature. In headwater streams in British Columbia, 10 m (33 ft) riparian zones generally minimized effects to stream temperature from timber harvest, although maximum daily temperatures reached 3.6°F higher than control streams (Gomi et al. 2006). It should be noted that intermittent and ephemeral streams that naturally go dry during summer months will likely have minimal impact on downstream summer temperatures. Another study of streams in Washington found that stream temperatures were most closely correlated with vegetation parameters associated with the riparian area, such as total leaf area and tree height, and that the effect of buffer width was less significant, particularly for buffers larger than 30 m (98 ft) (Sridhar et al. 2004). These findings are consistent with an earlier study relating angular canopy density (ACD), a proxy for shading, to riparian buffer width. The study found that the correlation between shade and riparian buffer width increases approximately logarithmically, reaching an asymptote around 30 m (98 ft) (Bestcha et al. 1987). Therefore, for buffers less than 30 m (98 ft), buffer width is expected to be more closely related to shading and stream temperatures than buffers over 30 m (98 ft). A study in British Columbia found significant cooling of up to of 4°C in reaches downstream from logged areas even in relatively short lengths of shaded stream channel (200 m [656 ft] long); however, significant cooling was largely attributed to the cooling effect of groundwater in the shaded reaches (Story et al. 2003).

In addition to effects of shading and microclimate, water temperatures may vary at the site or reach scale depending on substrate conditions and the effects of hyporheic (subsurface) flow and groundwater seeps (Ebersole et al. 2003, Johnson 2004, Janisch et al. 2012). Thermal heterogeneity resulting from localized groundwater sources or hyporheic flow may provide localized habitat refugia for cool-water fish (Ebersole et al. 2003). Similarly, portions of intermittent channels that consist entirely of hyporheic flow (no surface water) may provide thermal resilience by maintaining cool water temperatures despite loss of adjacent forest cover (Janisch et al. 2012).

In addition to the effect of riparian areas, watershed-scale land uses can affect stream temperatures. For example, a study in British Columbia found that, after accounting for the effects of watershed size, air temperature, and elevation, the density of roads in a watershed was positively correlated with the summer maximum weekly average water temperature (Nelitz et al. 2007). In areas where headwater wetlands naturally moderate stream temperatures, these wetlands also tend to mitigate the effect of forest clearing on downstream temperatures (Rayne et al. 2008).

Edge effects extend well into the forest, and affect microclimate. Therefore riparian buffer effectiveness at maintaining microclimate is also influenced by edge effects. One study in western Washington detected microclimate edge effects along the entire length of a 240 m (787 ft) buffer (Chen et al. 1995). Heithecker and Halperin (2007) found that most changes in light occurred within 20 m (66 ft) of the forest edge, and that air and soil temperatures stabilized within a range from 10-30 m (33-66 ft); but that throughout 1-hectare forested plots, air temperatures remained elevated compared to larger control plots. Another study in Western Washington found that buffers ranging from 16-72 m (52-236 ft) did little to limit elevated air temperatures associated with an adjacent clearcut in mid-summer (Dong et al. 1998). In contrast to these studies, a study of small streams in Western Washington indicated that buffers greater than 45 m (147 ft) wide are generally sufficient to protect riparian microclimate at streams (Brosofske et al. 1997). In summary, edge effects on forest microclimate extend well into forested areas adjacent to clearings and traditional riparian buffers are not expected to attain pre-disturbance microclimate conditions unless they are several hundred meters wide, but buffers ranging from 10-45 meters (33-147 ft) in width may minimize microclimate effects related to light, soil, and air temperatures.

Two studies in the Pacific Northwest considering the effects of partial forest retention on microclimate found that retention of 15 percent of a forest basal area was not sufficient to maintain microclimate conditions (Heithecker and Halperin 2006, Aubry et al. 2009); however, 40 percent basal area retention resulted in cooler mean air temperatures than clearcut conditions and light conditions similar to an undisturbed forest (Heithecker and Halperin 2006).

In Island County, the County's Water Quality Monitoring Program measured temperature at 19 sites in 16 watersheds between 2006 and 2011. While nearly all of the sites met state temperature standards, two salmonid bearing streams, Upper Maxwelton Creek, and Upper Kristoferson Creek consistently exceeded temperature standards during summer months. Both systems contain fairly low gradient streams with slow-moving water, and little to no riparian cover over the channel at the monitoring location. Additionally, the monitoring locations at both sites are located down stream of relatively large ponds or wetlands. Both of these systems are the focus of targeted additional monitoring with the goal of improving water quality for fish and wildlife, as well as opening closed shellfish beds and swim beaches downstream (Island County Environmental Health, 2013, internal draft).

5.6 Open Water Features

Ponds and lakes are vital habitat components for bald eagle, peregrine falcon, osprey, and great blue heron in Island County. These species all rely on the proximity of these features for some or all of their lifecycle. Herons in particular often nest near open-water wetlands. Preservation of forest stands, native shrub, and large trees near open water are critical to providing potential nesting habitat for these species as well.

The open areas above ponds and lakes are ideal foraging habitat for a number of swift and swallow species. Bald eagles and peregrine falcons regularly forage on ducks and other birds that utilize open water. Reptiles and amphibians that breed and rear in ponds and lakes are important as primary and secondary prey species to a variety of wildlife, beyond the species of local importance mentioned here.

Development can substantially alter terrestrial input to lakes, including large wood (Francis and Schindler 2006), terrestrial insects (Francis and Schindler 2009), and organic detritus (Francis et al. 2007). Whereas 40 percent of fish in undeveloped lakes consumed insect prey, only 2.4 percent of fish consumed insect prey in developed lakes (Francis and Schindler 2009). These changes can substantially alter shoreline structure and food-web linkages in lakes and open-water features. Most of the lakes in Island County were developed for residential use prior to the adoption of existing critical areas regulations. As a result, there is little opportunity to protect existing developed lake and pond shorelines.

Crockett Lake and Swan Lake support several avian species of interest (see Table 1), as well as large numbers of migrating shorebirds. The majority of the watershed draining to Crockett Lake is in private ownership. Oak Harbor, one of the more intensively developed areas in the County occupies portions of the Swan Lake watershed. Increased impervious surface in these basins may increase the risk of flooding in the lake, and potentially raise levels of contaminants.

6 Marine and Estuarine Habitats and Potential Effects of Development

6.1 Sediment Transport

Sediment transport in the marine nearshore is primarily driven by bluff erosion and shoreline drift processes (Johannessen and MacLennan 2007). Approximately 50 percent of Island County's marine shorelines are identified as active or historically active feeder bluffs (Johannessen and Chase 2005). Approximately one quarter of the historically active feeder bluffs in the County (12 percent of the County's shorelines) have been modified, usually by bulkheading at the toe of slope, such that feeder bluff contributions to marine nearshore sediment are now impaired (Johannessen and Chase 2005). Eight percent of the County's marine shorelines are described as exceptional feeder bluffs, meaning that they have eroding bluff segments with the highest volume of sediment per shoreline length in the County.

Development at the top of bluff can accelerate natural bluff erosion by modifying the hydrology, loading the top of a bluff, and removing stabilizing soil and vegetation (Shipman 2001, 2004). In addition to the routing of stormwater from impervious surfaces associated with bluff-top development, on-site septic systems associated with bluff-top residences introduce significantly more water into the bluff soils. Bluff-top development that collects runoff in drains and routes the stormwater over the face of the bluff via pipes can limit the super-saturation that can exacerbate bluff failures, but these systems can be undermined by any leaks in the pipe system (Shipman 2001, 2004). In a study of the landslides in the City of Seattle, Shannon and Wilson (2000) concluded that 84 percent of landslides in the city were associated with some level of human influence. Marine riparian vegetation also helps to stabilize marine shorelines to limit episodic failures of bluffs (Desbonnet et al. 1994; Brennan and Culverwell 2004). If this vegetation is removed, bluff retreat may accelerate, threatening upland development and/or instigating new shoreline armoring. Removal of marine shoreline vegetation may also increase substrate temperatures in the upper intertidal zone, adversely affecting forage fish spawning success (Rice 2006) and secondarily impacting piscivorous and partially piscivorous species that forage in marine waters, including brown pelican, common loon, bald eagle, and marbled murrelet. Murrelets in particular are sensitive to shifting food supplies. Marine riparian vegetation also contributes organic detritus and terrestrial insect production, which is used as a food source by juvenile salmonids (Brennan and Culverwell 2004)

The natural process of bluff erosion and deposition on beaches is vital to maintaining natural beach characteristics and functions in Puget Sound (Johannessen and MacLennan 2007, Parks et al. 2013). Beach systems provide a range of functions including submerged aquatic vegetation (Mumford 2007), shellfish production (Dethier 2006), sources of prey for salmon and shorebirds (Fresh 2006), and obligate beach spawning forage fish in high beaches (Penttila 2007). Bluff erosion results in the gradual or episodic loss of land at the top of bluffs. If development is built in close proximity to the top of bluff, shoreline protection may be subsequently be desired and constructed, even though evidence supporting the value of shoreline armoring at the toe of slopes is overestimated (Shipman 2001).

One of the unintended consequences of shoreline armoring is that it prevents bluff material from being incorporated into the shore drift system, limiting the drift sediment available for maintenance of beaches. Additionally, where shoreline armoring occurs, it typically results in accelerated erosion and slope instability at adjacent sites and at the toe of the bulkhead, steepening and coarsening of the shoreline, reducing beach wrack, and altering benthic invertebrate communities (Williams and Thom 2001, Finalyson 2006, Sobocinski et al. 2010).

6.2 Woody Debris

Large wood in estuarine and nearshore areas helps to stabilize shoreline sands and gravels in the upper intertidal (Eamer and Walker 2010) and to create topographic and vegetative diversity in tidal marshes (MacLennan 2005, Hood 2007). Large wood in estuaries is also used as perches by several priority birds within the County, including bald eagles, great blue heron, and brown pelican (Gonor et al. 1988). In the Skagit River estuary, Hood (2007) determined that much of the wood was so large that it must have been derived from upstream sources. As a result of limited wood transport and mobility in small stream channels (May and Gresswell 2003), large wood deposited on shorelines and in estuarine marshes are likely related to drift cell processes, bluff erosion, or significant flood events, such as those associated with large beaver dam failures. In two marshes in Puget Sound, Elger Bay on Camano Island and Sullivan-Minor Marsh in Padilla Bay, MacLennan (2005) found a predominance of anthropogenically derived woody debris, primarily deposited during periods of peak timber harvest (MacLennan 2005). This result is consistent with the finding by Gonor et al. (1988) that LWD sources have shifted from natural to logging-related debris. MacLennan (2005) suggests that large wood may act as a disturbance mechanism for vegetation, and in moderate quantities, this disturbance generates habitat heterogeneity (Gonor et al. 1988).

7 Terrestrial Habitats and Potential Effects of Development

While management and land use actions and decisions are necessarily conducted at local and site scales, an understanding of landscape scale conditions and processes is vital to effectively addressing more local habitat considerations. Landscape-scale mechanisms influence and may explain patterns of species distribution and abundance (Cushman 2006). A strong example of the influence of landscape-scale factors on local habitat and wildlife, including FWHCAs, can be seen in connectivity effects on local habitat (see Section 1.5). The benefit of connected habitat areas to wildlife is evident, as habitat corridors facilitate the movement of individual animals and connect even distant "source" areas to local habitat patches. Another benefit of habitat connectivity includes maintaining genetically diverse populations that are more resilient to disturbance and extirpation. An understanding of the existing landscape and evident wildlife responses to landscape condition and use can inform local management decisions, as it both provides an opportunity to understand current local habitat use and to aid in determining the potential for meeting management goals.

7.1 Landscape-Scale Impacts of Development

The amount and quality of upland native habitat is influenced by the expected and regular actions of that occur as part of development, land use, and land management. As structures, roads, yards, and other man-made features perforate the landscape, suitable habitat becomes less available in absolute area and remaining habitat becomes isolated in patches or fragmented, often to the detriment of wildlife (Marzluff and Ewing 2001). Development in vegetated areas has the immediate impact of removing habitat for individuals, and in some cases populations, of species present in the area. Extirpation of animals dependent on large forested tracts, for example, occurs when a habitat patch is reduced below the needed area; further, the reduced population will at some point be unable to support a viable population of area-sensitive species and may become a "sink."

Urbanization generally causes more persistent and drastic fragmentation than other anthropogenic land uses, such as forestry and agriculture, as fragments are commonly separated by impervious surface, structures, impassable barriers, and infrastructure used by vehicles and people. Water flow is obstructed or redirected, nutrient cycling is disrupted, and ecological function may be interrupted or altered. Total habitat area is reduced; dispersal and travel by many wildlife species is altered or obstructed; and the processes of predation, parasitism and interspecies competition are affected (Marzluff and Ewing 2001). Isolated habitat fragments tend towards degradation and the establishment of non-native habitat (Marzluff 2001). Proximity of development, in addition to habitat loss, has been demonstrated to impact some taxa, such as native grassland rodents, when it disrupts habitat (Bock et al. 2002).

Agricultural development has been responsible for the loss of entire habitats in the United States, and secondarily leads to increases in edge, fragmentation, structural and compositional simplification, and establishment and proliferation of non-native and invasive vegetation (Southerland 1993). In Island County, agricultural development of fertile prairie soils has been a key cause of loss and fragmentation of prairie habitats and impacts to prairie species. As with other habitat types, reduction of prairie habitat can result in direct loss of wildlife species (Herkert 1994), and impacts due to the secondary effects listed above can result in higher predation rates on waterfowl and reproduction impacts (Pasitschniak-Arts and Messier 1995, Herkert et al. 2003). On the other hand, fallow fields and flooded pastures can help provide foraging habitat for wintering migratory waterfowl, (Ball et al. 1989).

Birds are probably the most-studied taxon in urbanizing areas. Although they are more mobile than most other terrestrial wildlife, they often exhibit population responses to the habitat changes associated with development. Long-term viability of avian populations appears to be lowered by reduced quality, abundance, and connectivity of native forest in urbanizing areas (Belisle et al. 2001, Donnelly and Marzluff 2004). In the Vancouver British Columbia area, Melles et al. (2003) showed an inverse relationship between species richness and level of urbanization, with local- and landscape-scale attributes exerting an effect. In this study, the presence of large conifers, berry-producing vegetation, and streams increased the likelihood of recording birds on the local level, and forest cover improved the chances of observation. In many cases, relationships are non-linear, with density and richness peaking at intermediate levels of disturbance. This phenomenon often was the result of varying levels of adaptability of species to disturbance.

In a summary of the existing literature, Marzluff (2001) reported that human-driven land use cover changes that occur with development have generally resulted in increases in non-native bird species, increases in species that nest in human structures, increased nest predation, and decreases in forest-interior and ground-nesting species. Factors favoring increases in non-native species and those nesting regularly in human structures were primarily increased food, and less importantly, fewer predators, less persecution by humans, and habitat enhancement. Factors driving declines in forest-interior and ground-nesting species were decreased available habitat, reduced habitat patch size, increased edge habitat (the interface between different vegetative communities or habitat types), increased non-native vegetation, decreased vegetative complexity, and increased nest predation. Loss of important habitat features such as snags has also reduced density of birds (cavity-nesters) in urbanizing areas (Blewett and Marzluff 2005).

Habitat loss and fragmentation are leading causes in the global decline of amphibians (Becker et al. 2007). The level of urbanization also impacts some amphibian species, reducing abundance and species richness (Rubbo and Kiesecker 2005). Forest removal impacts migration and dispersal from wetlands, and effects may occur regardless of efforts to reduce the impact of specific silvicultural practices (Todd et al. 2009).

7.2 Patch Size and Isolation Effects

The pattern of habitat loss and resulting fragmentation may exert a greater influence on declines in wildlife populations, including birds, mammals, and insects, than habitat loss alone (Bender et al. 1998). Biodiversity as a whole, however, may be impacted less by fragmentation than habitat loss (Fahrig 2003).

Isolated terrestrial habitat patches resulting from fragmentation were predicted to support more species as the size of the patch increases (Adams 1994). This model held true for woodland birds, chaparral birds, land vertebrates, flies, and beetles. The influence of patch size has been further investigated in more recent literature, with greater consideration of landscape parameters, scale, and other potentially confounding factors. For example, Donnelly and Marzluff's (2004) work in the Seattle metropolitan area shows evidence that species richness increases with habitat patch size in a range of residential land use intensities (urban, suburban, and exurban [outer urban fringe]) because large reserves are able to support more species drawn from the regional pool. Large reserves in more developed areas supported greater species richness than large exurban reserves because of their ability to recruit and support synanthropic species, or those that adapted readily to human presence, that were generally not present in exurban areas. As well, larger reserves can be expected to contain greater habitat diversity and subsequently more niches for species to utilize. Donnelly and Marzluff (2004) attributed the differences in species richness between large and small reserves to local extinctions. As reserve size decreased, those species depending on intact or expansive forest were the first to disappear. A tendency for some neotropical migrant bird species to decline in smaller forested areas was observed as well. Small mammals have also showed a higher likelihood to immigrate to larger fragments when faced with smaller alternatives (Diffendorfer 1995).

A similar effect was demonstrated in forest-interior birds in southeast Alaska (Kissling and Garton 2008). Very large reserves supported most native forest bird species found in the area, while reserves within landscapes of high (>40%) urban cover supported most of the synanthropic species found here. In summary, forest species occurrence decreased with decreasing habitat patch size, and synanthropic species occurrence increased with the amount of urbanization in the surrounding landscape. Non-native groundcover explained much of this variation as native forest species decreased and synanthropic species increased with the amount of exotic ground vegetation. The complex juxtaposition of habitats in more urban landscapes seems to allow for the occurrence of synanthropic species in urban reserves.

Less mobile species with small home range sizes are more sensitive to habitat patch size than relatively mobile species, such as birds. Higher small mammal abundance and/or richness has been demonstrated in larger patches (Pardini et al. 2005) and in patch interiors (Orrock and Danielson 2005), and amphibians may show a positive response to buffers that increase habitat patch size (see *Corridors and Buffers* section). While species requiring smaller home ranges throughout their lifecycle may initially respond less negatively to habitat loss than species that generally need larger areas, this seeming resilience may be short-lived. While a lesser impact has been demonstrated in amphibians with lower dispersal abilities than those with greater abilities, the more tolerant species are likely to face equally negative consequences with time (Cushman 2006). Mammals and insects exhibit a similar varied response to patch size depending on life history strategies. Edge and interior species exhibit positive and negative responses, respectively, to decreasing patch size (Bender et al. 1998).

Large forest patches in the greater landscape may be important to adjacent developed areas in that they act as “sources,” protecting the long-term survival of species that may use urban areas but cannot exist without larger habitat patches in the greater vicinity. Similarly, in North Carolina development-sensitive bird species richness and abundance decreased with increasing cover of managed (mowed or cleared) area within and adjacent to forested greenways, with most sensitive species persisting only in the widest remaining forested tracts (Mason et al. 2007). In contrast, fragmented habitat matrices are a major influence on urban habitat patches as a source of invasive plants and predators (McKinney 2002). They may eventually become “sinks,” or areas unable to support viable populations of particular species or other taxa.

Despite higher species richness in the large reserves, the relative abundance of birds was greater in habitat patches in urban and suburban landscapes than in more rural landscapes (Kissling and Garton 2008). The authors suggest that density increased because individual forest birds pack into reserves when forest habitat is scarce, increasing densities. Individuals are more able to disperse when reserves are bigger, evidenced by the tendency of lower densities in larger reserves. In smaller habitat patches, increased densities could result in density-dependent interactions such as greater competition for resources.

Small reserves may support one or more life history phases (e.g., foraging or rearing), but they may not be sufficient for species to complete their life cycles. For example, Kissling and Garton (2008) found that small forest patches in urban landscapes had no value as breeding areas for some forest bird species. The highest shrub nest densities, apart from those in large, exurban reserves, were observed in medium-sized (mean of 34.7 ha) suburban reserves. These considerable habitat patches potentially act as a means of retaining forest species in developing landscapes. Corridors may facilitate wildlife travel between small forest patches, but vegetated corridors are not always effective, particularly for migratory birds (Hannon and Schmiegelow 2002) (See *Corridors and Buffers* section).

In some cases, such as prairie habitats, because extinctions and biodiversity often lag behind habitat loss and fragmentation, even if all existing habitat area is conserved, it is not sufficient to sustain the remaining prairie biodiversity (Floberg et al. 2004). This finding indicates that habitat restoration may be needed in some cases, such as prairies, in order to conserve existing biodiversity. The authors also note that where conservation of habitat area is supplemented by directed conservation of vulnerable species, species biodiversity will also be enhanced as those vulnerable species act as umbrella species for species not specifically targeted for conservation (Floberg et al. 2014).

7.3 Gaps, Edge, Roads, and Disturbance

In addition to patch size and isolation effects, particular species and guilds may show varying sensitivity to patch isolation, habitat quality within the patch, landscape characteristics surrounding patches, and species interactions with other wildlife using the landscape. Even small breaks between habitat patches can deter wildlife travel and, in some cases, directly impact wildlife abundance. For example, the relatively small gaps from bridges, perhaps coupled with the disturbance of vehicles and noise, were associated with decreases in riparian bird species richness and density (Lens and Dhondt 1994, Machtans et al. 1996).

Fragmentation has been shown to be detrimental to migratory bird species in many studies, although it should be noted that increased edge is an inevitable consequence of fragmentation and often confounds, and may skew, results (Parker et al. 2004). Less mobile species, such as invertebrates and small mammals, often exhibit a more profound response to development than more mobile species (Hansen et al. 2005), and they might be expected to be more greatly impacted by fragmentation. On the other hand, bird population dynamics may be related to amount of vegetated area available rather than configuration because birds are highly mobile and able to travel between disjunct patches (Marzluff 2005). However, some mobile species (e.g., songbirds) exhibit a preference for traveling between habitat patches through wooded areas compared to open gaps, even when the wooded route was up to three times longer than the gap (Desrochers and Hannon 1997).

For highly mobile species, the size of gaps between forest patches determines the effects on the species. Forest songbirds in an urban landscape in Alberta were significantly more likely to move between vegetation patches when gaps were <30 meters (<98 ft), and the difference was more dramatic when gaps reached 45 m (147 ft) (Tremblay and St. Clair 2009). Traffic also reduced movement. Probably due to relative width, railroads had a lesser effect, and rivers had a higher impact than anthropogenic linear features. On the other hand, small mammals moved between fragments in lower numbers as fragmentation increased, but tended to move greater distances (Diffendorfer et al. 1995).

The location of roads among habitat patches can impact wildlife using the patches. Fahrig et al. (1999) documented a proportional increase in frog and toad mortality with traffic intensity on roads, and suggested that mortality contributed to decreased abundance in areas of high-intensity road use. Lehtinen et al. (1999) also found that road density was associated with a decline in amphibian species richness. While terrestrial habitat exerted the greatest influence on the occurrence of amphibian species and community richness on a local scale (50-400 m [164-1,312]) in northern Italy, the presence of roads also had a significant effect on a larger spatial scale (300-1500 m [984-4,921 ft]) (Ficetola et al. 2008), demonstrating that buffer regulatory decisions should take into consideration the amount and type of development and land uses across the landscape. Neotropical migrant bird abundance, richness, and diversity have been associated with areas containing the fewest roads in Portland, Oregon (Hennings and Edge 2003). A 1997 review of literature recommended retaining forest with few roads adjacent to wetlands in order to minimize disturbances to birds resulting from access (Azous and Horner 1997).

Habitat fragmentation can limit genetic interchange with previously connected population segments, resulting in genetically isolated populations. For example, major roads have presented a barrier to movement and interbreeding in flightless beetles, resulting in reproductive isolation and genetic differentiation (Keller 2003, 2004). Similarly, road density and major road occurrence are correlated with genetic divergence among patches in frogs (Arens 2007, Crosby et al. 2009). Genetic convergence has been observed in lizards and birds among habitat patches in a fragmented landscape (Delaney 2010). As fragmentation results in reduced genetic diversity within patches, it can result in inbreeding and reduced fitness (Andersen et al. 2004). Because genetic convergence is inversely related to patch size, larger patches will tend to support more diverse gene pools and correspondingly more resilient populations (Andersen et al. 2004, Dixo et al. 2009).

Replacing native vegetation with maintained lawns negatively affects bird and butterfly abundance and species richness (Nelson and Nelson 2001). Increased non-native vegetative cover, including ornamental species used in landscaping, was one of several factors that simultaneously led to reductions in the number and quality of urban songbird nest sites in several studies, and exotic shrub cover was correlated with an increased risk of nest predation (Marzluff 2001). Exotic ground and shrub cover was locally associated with a decrease in forest bird species and an increase in synanthropic species in the Seattle area, although whether these changes were also the result of other concurrent effects of urbanization was unclear (Donnelly and Marzluff 2004). Ironically, dispersal of non-native plant species may be facilitated by birds in the urban landscape, leading to the propagation of discrete infestations (Reichard et al. 2001).

7.4 Wildlife Guilds and Adaptation

Bird and mammal studies show that species have different ways of adapting to drastic changes with urbanization. Urban avoiders, in roughly decreasing order of sensitivity, are rare species with low reproductive rates, large mammals, old-growth and mature forest species, insectivorous tree foragers, neotropical migrant birds, and ground-nesting birds (McKinney 2002). These species and guilds are generally the first to be excluded from urbanizing areas, although sensitivity to urbanization is not always apparent (Oneal and Rotenberry 2009).

Species and guilds that are often able to adapt to human-induced changes include edge species, omnivores, ground-foragers, seed-eaters, aerial sweepers, tree/shrub/cavity nesters, burrowing mammals, and human food eaters. These "urban adapters" benefit from the interspersion of habitats that residential development often results in, including edges created where open areas or maintained properties meet native forest (Adams 1994). They are able to utilize native resources, as well as foods that are available as a result of human presence. These include intentionally provided bird foods, seed- and fruit-producing landscape plants, and garbage. Aerial insectivores probably take advantage of open areas and artificial lights that attract insects (although Blair (1996) noted the loss of native insectivorous birds from built areas in California); seed-eaters benefit from both landscape plants and birdfeeders; and omnivores, corvids in particular, seem able to exploit garbage sources (McKinney 2002). Species, including some swallows and wrens, that are able to nest in man-made structures find an abundance of nest sites in urban habitat, and these species increase with some types of fragmentation and disturbance (Rottenborn 1999). The availability of human-introduced resources is one of the reasons that abundances of urban-adapters tend to be higher than found in natural situations (Adams 1994, Marzluff 2001). Because urban adapters are not typically of significant conservation concern, the tendency of more highly tolerant species to displace or out-compete native species is of concern when management goals include preserving biodiversity or vulnerable species in developing areas.

Finally, the proliferation of synanthropic species occurs as development infringes on the landscape, leading toward a more homogeneous fauna. Although during intermediate stages of development, when cleared areas intersperse with forest patches to produce edge, species richness peaks for some groups, including songbirds (Blair 1999, Marzluff 2005), the effect disappears as development becomes denser.

As a developing area that generally comprises urban and mixed environs, westside lowland conifer-hardwood forest, and agriculture/pasture/mixed environs habitat types, with numerous wetlands and streams (Johnson and O'Neil 2001), Island County presently supports a wide range of wildlife species and taxa. The potential for land use actions to enhance or diminish suitability for sensitive species, synanthropic species, species of local interest, and pest species can be addressed through an understanding of how various guilds adapt and respond to changes. This will aid in efforts to protect species during the planning process.

7.5 Corridors and Buffers

One solution to the negative impacts of fragmentation is to manage connectivity (Schaefer 2003). Connectivity refers more to the ability of a species to traverse or reproduce across an area than any innate condition of the habitat itself. It can refer to the intactness of a patch or expanse of habitat (in contrast to fragmented habitat) or to a travel corridor between larger habitat patches. It is becoming increasingly apparent that landscape configurations are an important factor in species occurrence and distribution (Rodewald 2003). Different wildlife species perceive and use any particular habitat patch or configuration of patches differently. The more that individual patches and groups of patches facilitate movement or provide needed life cycle support for the particular species, the more connected the landscape is for that species. Small terrestrial organisms require separate consideration from more mobile large mammals and birds.

Vegetated corridors tend to be correlated with watercourses in urbanizing settings, in part because of regulatory protections on streams and rivers. The associated riparian systems make up a relatively small percentage of land cover in the western United States, yet they provide habitat for rich wildlife communities (Knopf et al. 1988, Johnson and O'Neil 2001, which in turn provide a source for habitat patches or reserves. Consequently, streams in urban areas can support rich wildlife communities (Johnson and O'Neil 2001), with implications for the use of buffers to preserve biodiversity. In Island County, there is presently one PHS-designated Biodiversity Area and Corridor, consisting of steep forested slopes and bluffs topped by forest along Holmes Harbor (Map 4).Many studies address the importance of vegetated corridors to wildlife, particularly in developed areas (Knopf et al. 1988, Gillies and St. Clair 2008, Gilbert-Norton et al. 2010)). They are particularly valuable in fragmented habitats because they can facilitate travel among habitat patches for wildlife. Riparian corridors may also play a role in maintaining microhabitat and suitable microclimates for species associated with streams (Klubar et al. 2008). A 1998 synthesis (Beier and Noss 1998) concluded that while the results of previous empirical studies had been affected by confounding factors, results of the best-designed studies suggested that corridors contribute to wildlife conservation. Subsequent studies demonstrate the value of habitat corridors, as well as the potential risks of creating habitat sinks (Hilty et al. 2006). The number of wildlife species has been demonstrated to be directly proportional to corridor width (Dickson 1989, as cited in Keller et al. 1993), although other studies show conflicting results (Pearson and Manuwal 2001) and species-specific variation (Ficetola et al. 2008). In environments similar to those in Island County, published results pertain to a wide range of taxa, including birds, small and large mammals, herptiles, and insects. The widespread occurrence of streams and other features that may contribute to habitat corridors in the County create the opportunity to apply corridor study results to management strategies and decisions. The width and composition of habitat corridors may affect their function. For example, in northeastern Missouri, breeding bird species richness was greater in wider forested riparian areas in than narrower strips, and richness was greater in narrow riparian strips with grassland-shrub buffers than in narrow strips without vegetated buffers (Peak and Thompson 2006). Conversely, synanthropic bird species richness and abundance have been correlated with the narrowest of preserved forest corridors studied (Hennings and Edge 2003, Mason et al. 2006).

Recent synthesis papers have summarized the results of primary studies on corridor and buffer width needs for wildlife in urban and urbanizing areas. Terrestrial buffers on streams and wetlands are particularly important for reptiles and amphibians, as they depend on these areas for certain lifecycle stages (Azous 1997). A 2003 synthesis found that terrestrial core habitat (buffers associated with wetlands) of 159-290 m (522-951 ft) and 127-289 m (417-948 ft) in width were required by amphibians and reptiles, respectively (Semlitsch and Bodie 2003) while a primary study that four species of stream breeding salamander in Appalachia required buffer widths of 77 m (253 ft) to provide habitat and buffer edge effects (Crawford and Semlitsch 2006). Buffers of 92.6 m (304 ft) were recommended to accommodate the farther-ranging individuals. Amphibians in northern Italy required riparian buffers of 100-400 m (328-1,312 ft) in width (Ficetola et al. 2008).

Most studies report a range of 125 to 400-meter-wide (410-1,312 ft) corridors necessary to provide essential habitat for avian species (Shirley and Smith 2005, Peak and Thompson 2006, Kissling and Garton 2008). Other work suggests that vegetative structure in corridors (sometimes in conjunction with buffer width) explains use by birds (Pearon and Manuwal 2001, Shirley 2006). Based on songbird studies, while wide corridors are optimal, management efforts should focus on restoring or creating vegetated riparian areas along streams that currently lack vegetation, as even narrow buffers have been shown to provide habitat for many species (Pearson and Manual 2001, Keller et al. 1993).

The likelihood of small mammals to respond to the presence of vegetated corridors varies among species. A preference for connected habitat patches implies a use of corridors in some species (Pardini et al. 2005), and some species respond in a strong positive way to corridors (Lanoue 1988 *in* Gilbert-Norton 2009), while others exhibit avoidance (Orrock and Danielson 2005). In a fragmented landscape, corridors did not influence home range size in some small mammals, whereas the species' habitat needs and sex influenced its likelihood to move among patches (Mabry and Barrett 2002). As well, the position of corridors relative to patches and the overall increase in habitat area that they create may result in a positive response in captures of some small mammal species (Orrock and Danielson 2005).

A 2010 review of the literature found that corridors most effectively facilitated movement or dispersal through fragmented landscapes by invertebrates, plants, and non-avian wildlife (Gilbert-Norton et al. 2010). This work showed that use of corridors was not influenced by independent variables such as total vegetated area. Most research indicates that landscape- and watershed-scale elements, including patch size and landscape positioning, should be considered in determining effective buffer widths, as parameters measured at these greater spatial scales can impact wildlife occurrence and population dynamics (Ficetola et al. 2008, Rubbo and Kiesecker. 2004, Willson and Dorcas 2002).Finally, despite the potential benefits of habitat corridors, it should be noted that as a result of their high edge-to-area ratio, corridors may facilitate the establishment of invasive species and access by predators, and they generally provide smaller buffers from disturbance than non-linear habitat patches.

Adamus analyzed alterations to wetlands and their buffers (Adamus, 2006). From 1985 to 1998, based on aerial imagery interpretation, 11% of wetlands analyzed were found to have been altered by development or clearing. The proportion of 100-foot buffers found to have been altered during this timeframe was 24%. These rates of alteration decreased between 1998 to 2005 to 8% for both wetlands and their 100-foot buffers. Adamus also included data from timber harvest permits which showed that since 1996 7% of wetlands and 12% of their 100-foot buffers had been subject to timber harvest (Adamus, 2006). It should be noted that many types of alterations are not detectable using aerial imagery.

Conservation corridors have been developed for consideration as a part of Island County's Comprehensive Plan, Element 7 Parks and Recreation. As a part of this process, key conservation criteria and priorities were identified within Island County. Adjacency to existing protected lands for conservation value, the presence of critical areas, the presence of rare and endangered species and habitats, as well as existing conservation priorities were all considered in the development of the conservation corridors map that is includes as a part of Element 7 of the Parks and Recreation of the Island County Comprehensive Plan. In addition, habitat conservation criteria were determined throughout Island County (Island County Comprehensive Plan, 2011).

7.6 Invasive and Non-native Species

As noted above, infestation by invasive and non-native species is often a consequence of urbanization and other development (McKinney 2002, Southerland 1993, Zedler and Kercher 2004). Detrimental consequences of infestations to native species and habitats may include extirpation of species (Ricciardi et al. 1998), impacts to wildlife species and communities (Olden et al. 2004, Pimentel et al. 2005), and food-web simplification (Olden et al. 2004). These effects can take place at levels ranging from populations to ecosystems.

Under altered disturbance regimes of anthropogenic origin, invasive plants are able to increase their performance over native plant species (Daehler 2003). Noxious plant species can compete successfully for natives for pollinators (Brown and Mitchell 2001, Brown et al. 2002) and cause changes in fire regime (Brooks et al. 2004). In prairie ecosystems, invasive plants can modify soils to facilitate conditions favorable to themselves and other invasives (Jordan and Larsen 2008). This is of particular concern in Island County, where only small areas of prairie remain. As well, wetlands appear to be particularly vulnerable to infestation by invasive species, possibly due to factors including inflows of plant material in surface flows from urban and agricultural areas, dispersal along rivers, and hydrological disturbance that affect nutrient availability (Zedler and Kercher 2004).

A list of noxious weeds occurring in Island County is available on-line at http://county.wsu.edu/island/nrs/noxious/Pages/icweeds.aspx. The five most common noxious weeds in Island County are tansy ragwort, poison hemlock, purple loosestrife, spartina (anglica), and Canada thistle (http://county.wsu.edu/island/nrs/noxious/Pages/icweeds.aspx).

Adamus documented that of the 102 wetlands analyzed, 55% had between 1-24% cover of non-native plant species (Adamus, 2006).

8 DATA GAPS

1. Many of the referenced studies are based on evaluation of perennial stream channels. The ecological relationships and processes in intermittent streams may differ because of differences in the seasonality of sediment transport processes and habitat use.
2. Species occurrences and habitat locations are not comprehensively documented or mapped throughout the County, limiting the ability to track population trends and to identify and protect vulnerable species.
3. Systematic surveys of salmonid habitats and populations in the County are largely lacking. Recent research has identified non-natal salmonid use of the lowermost segments (200 m (656 ft) or to first fish passage barrier) of streams in Island County. In those streams without fish passage barriers in the lowest 200 m (656 ft) of streams, the upstream extent of non-natal salmonid use is unknown.
4. Systematic surveys of fish and wildlife populations, abundance, and distribution in Island County are largely lacking.
5. Systematic stream mapping and water typing has not occurred throughout the County. This affects water quality standards (e.g., primary contact, secondary contact), so it is difficult to assign water quality standards and determine if standards have been exceeded. Similarly, it is difficult to identify and differentiate ditched streams versus wholly artificial, created ditches because there has not been a systematic comparison of existing and historic watercourses and because of a lack of clear guidelines for differentiating the two types of channels.

6. Ponds and lakes have not been quantified as a percentage of total land cover, nor has their specific use by wildlife been systematically documented.
7. Streamflow data on small streams draining into the Puget Sound is lacking. The connection between groundwater and surface water in Island County has only been studied on a case-by-case basis for water right applications (e.g., Maxwelton) (Island County 2005).
8. Data is lacking on the percent of impervious cover by watershed as mapped in Island County. This information could inform policy updates related to both regulatory and non-regulatory incentives to increase forest cover, and to promote biodiversity corridors.
9. Data is lacking on the specific effects of development on habitats and species in Island County.
10. Data on the presence, extent, and systematic control of invasive species within Island County is lacking.
11. The potential effects of future climate change on fish and wildlife in Island County are not well understood. Climate change may result in changes in the abundance and spatial distribution of species (Field et al. 2007). Climate change may also exacerbate the effects of development on water flow and water quality in a watershed (Kaushal et al. 2010).
12. Our understanding of human changes to the landscape is based on a limited number of on-the-ground surveys and spatial data with limited resolution and accuracy. The potential to conduct extensive habitat surveys through the County may be limited on properties in private ownership.

9 Summary of Management Implications

Consideration of landscape, riparian corridor, and site-specific conditions is recommended to effectively manage fish and wildlife in the County. The potential effects of development, as described in Section 3 are summarized at each scale in Table 2. By implementing management at appropriate, and potentially, multiple-scales of influence on varying species and habitats, management may be more effective compared to a more unilateral approach

(Fausch et al. 2002, Roni et al. 2002, WDFW 2009, Stanley et al. 2012). For the purposes of regulatory updates to the County's FWHCA ordinance, the appropriate scale of analysis should consider the landscape condition and riparian reach, but will need to be grounded within the site specific scale to translate to effective ordinance language. While regulatory updates capture site specific protection measures, it is important to ensure that policy updates undertaken as part of the 2016 Comprehensive Plan process include consideration of the landscape scale conditions. Integration of landscape-scale considerations has occurred in recent updates to critical area regulations within some other jurisdictions (e.g. King County, Thurston County, and City of Redmond), where stream buffers may be larger/smaller depending upon connectivity to special aquatic areas such as Puget Sound or other Shorelines of the State. Additionally, this sort of landscape-scale consideration is integrated into the Washington State Wetland Rating System, which evaluates landscape position and landscape functions to determine wetland classification, and corresponding level of protection (Hruby 2004). Other approaches that have been used to balance programmatic landscape-scale considerations with local-scale management include: density or impervious surface limits, clearing limits, conservation overlays, mitigation banking, and in-lieu fee programs.

9.1 Recommendations to Maintain Water Flow Processes

The following recommendations will help to limit the potential effects of development on water flow processes.

- Cluster development, reduce density allowances, and/or limit clearing to protect natural vegetative cover. Focus protection on headwater areas and wetlands (Booth et al. 2002; Morley and Karr 2002, Booth et al. 2004)).
- Limit watershed imperviousness and retain forest cover, either through minimal development, clearing and grading standards, or the use of LID approaches (Konrad and Burges 2001, Booth et al. 2004). (Figure 2 in Section 3.1 helps to clarify thresholds of impervious surface cover and forest cover that maintain stream conditions). Manage stormwater at local scales to help maintain natural flow frequencies and durations, (Konrad and Burges 2001).
- Ensure that riparian buffers are adequate to protect the structure and function of existing resources.

Table 2. Summary of management considerations for water flow, water quality, and habitat based on the scale of influence.

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
Water Flow	Watershed development and forest conversions alter water flow processes by increasing high flows, increasing variability in daily streamflow, reducing groundwater recharge, and reducing summer stream flows. Rural zoning and density limits help minimize effects of impervious surfaces, but even in rural areas, if forest loss is greater than 60 percent in a watershed, stream channels are expected to be unstable. Hydrologic alterations related to development tend to degrade stream morphology by decreasing bank and bed stability, resulting in incised, wider, and simpler stream channels.	Protection of hydrologic source areas and groundwater sources is particularly important for maintaining downstream hydrology.	Local scale effects on water flow processes are dependent on landscape position (see riparian scale). Local effects are most significant in the upper portions of watersheds. Low density development and low impact development measures can help limit the effects of development on water flow. Bluff-top development increases surface and groundwater inputs, reducing bluff stability.
Water Quality			
Sediment	Clearing and grading and any soil-disturbing activities contribute to fine sediment transport to streams. Watershed-scale studies have found that agricultural land uses are associated with the greatest	Convergence of sheet flow and piped stormwater systems can circumvent the effectiveness of riparian zones.	Sediment filtration capacity is significantly dependent on factors including soils and slope. Depending on those factors, buffers widths necessary for effective filtration range from 4-120 m (13-394 ft) wide. Buffers at the wider end of the range are needed

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
	production of fine sediment, followed by urbanized areas.		to control sediments on slopes of 10 percent or more and in areas with soils with a significant clay component. Buffers at the narrower end of the range effectively filter sediment from slopes of 2 percent with sandy loam soils. Fine sediments travel further than coarse sediments and need wider riparian zones (30-120 m or 13-394 ft) for effective filtration and long-term retention.
Metals, Pathogens, and other Contaminants	Cadmium, mercury, copper, zinc, and lead cause acute, chronic, and potentially lethal impacts to aquatic plants, invertebrates, fish, particularly salmonids, and seabirds. Municipal wastewater management and public education are important factors to limit the transport of pathogens and pharmaceuticals to the County's surface and groundwater resources.	The full suite of chronic and synergistic effects of metals and synthetic contaminants in field conditions is not well understood. Development can have significant, unforeseen effects on the health and survival of aquatic species. Pathogens associated with human and animal wastes present a significant health concern for contaminated shellfish consumption. Both point-source and non-point-source control of potential pathogen sources are required for effective management. Maximizing the distance of roads and septic systems from aquatic resource areas will help limit the	Relatively narrow buffers can effectively limit the transport of herbicides and pesticides through drift and runoff. Little additional benefit in herbicide filtration is gained from buffers wider than 18 m (59 ft). Best management practices during application of herbicides and pesticides can help limit leeching to groundwater. Stormwater system improvements to slow and infiltrate runoff could help reduce metals, herbicides, and pathogens entering aquatic systems.

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
		transport of metals and pathogens to aquatic systems. Clustering development, limiting road densities, and/or requiring greater use of permeable paving materials could help minimize impacts.	Local scale factors for controlling the transport of metals, pathogens, and pharmaceuticals are poorly understood.
Nutrients	Any activity involving applying nutrients in excess of plant needs (fertilizing lawns, golf courses are other examples) and clearing/exposing soil may result in significant nutrient loading. Watershed-scale studies have found that agricultural land uses are associated with the greatest nutrient loads; whereas nutrient loading associated with rural residential land uses may be relatively low. In Island County, agricultural areas are decreasing, but rural development is resulting in significant forest clearing.	Headwater streams disproportionately affect nutrient loading; therefore, buffers on headwater streams are particularly effective at lowering nutrient levels downstream. Adsorption of nutrients is reduced immediately following dredging of agricultural channels.	The rate of nutrient removal in riparian zones is dependent on soil composition, infiltration, riparian zone width, riparian composition, climate, landscape position, and the position of the vegetation relative to surface runoff flow paths. In general, buffers wider than 50 m (164 ft) remove nitrogen more effectively than buffers less than 25 m (82 ft) wide. Nutrient retention removes approximately 89 percent of nitrates in subsurface flow, regardless of buffer width, whereas 131 m (430 ft) buffers may be necessary to retain 90 percent of nitrates in surface flow. Forested riparian zones are generally most effective at filtering nitrogen and phosphorus, although alder-dominated buffers may increase soil nitrate.

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
			Riparian zones less than 15 m (49 ft) may contribute to nitrogen loading. Filtration capacity decreases with increasing loads, so best management practices that reduce nutrient loading will improve riparian function.
Terrestrial Habitat	Fragmentation creates sinks for some species, increases edge and disturbance, disrupts migration, favors synanthropic species, and promotes vegetative homogenization and invasive species establishment. Island and patch-size effects favor some species and negatively impact others,	Riparian wildlife species depend on the health and abundance of forage species, benefiting from efforts to maintain stream-dwelling fish and invertebrates. Reptiles and amphibians require vegetated riparian habitat for migration and dispersal. Corridors provided by riparian zones facilitate travel between habitat patches and provide habitat for some amphibian lifecycle stages.	Recommended corridor width to facilitate use by avian species ranges from 125-400 m (410-1,312 ft). Recommended corridor width to accommodate the furthest-ranging reptiles and amphibians in the U.S. is 77-289 m (253-948 ft). Protect rare habitats. Plan roads to minimize wildlife conflicts. Consider native vegetation retention, low-impact development, clustering, invasive species controls, habitat feature preservation, and other minimization techniques in planning and development.
Freshwater Habitat	Urban land uses, followed by agricultural uses, are associated	Headwater streams provide locally significant habitat, and they are	The probability of a tree falling into a stream decreases with increasing

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
	with degraded physical stream conditions and invertebrate indices. Buffers are less effective at maintaining stream conditions, including physical structure, invertebrate composition, and wood loading in more intensively developed watersheds. Management options such as limiting densities, clustering development, limiting impervious surfaces and clearing areas may minimize catchment-scale effects on freshwater habitats.	important to maintaining the condition of downstream areas. Avoiding development in these areas and in designated critical areas will limit impacts. Continuous riparian buffers help to minimize the effect of catchment-scale development on invertebrate communities and provide wildlife travel corridors.	distance from the stream. Most LWD originates within 15 m (49 ft) of the stream, but nearly 30 percent of LWD originated beyond 30 m (98 ft) from the stream. Additionally, trees beyond one site-potential-tree-height (SPTH) from a creek indirectly influence LWD recruitment. Riparian buffers of 30 m (98 ft) are generally sufficient to maintain sensitive invertebrate populations. Vegetation helps stabilize banks. Leaf cover and tree height may affect stream temperatures more than buffer width in buffers over 30 m (98 ft) in width. Buffers less than 10 m (33 ft) are generally ineffective at maintaining water temperatures. Buffer widths over 42-74 m (138-243 ft) may be necessary to maintain pre-existing microclimate conditions; and riparian areas ranging from 10-45 m (33-147 ft) will minimize microclimate edge effects.

	Management Considerations		
Process/Function	**Watershed-Scale**	**Riparian-Scale**	**Local Influence**
Marine and Estuarine Habitat	Nutrient, contaminant, and turbidity loads from freshwater streams negatively affect eelgrass, kelp, and shellfish beds, and may have both acute and chronic effects of marine fauna. Large woody debris supports beach stability and diversity of estuarine vegetation. In Island County, large wood is likely supplied by drift cell processes and bluff collapse.	Marine riparian vegetation supports bluff stability, provides nearshore detritus, and supports a temperature regime conducive to forage fish spawning habitat.	Development at the top of bluffs exacerbates erosion risk. Development at the top of bluffs may result in a proliferation of shoreline armoring, either as a result of a perceived threat or of accelerated erosion caused by the development.

- Protect riparian buffers and wetland zones, and minimize road and utility crossings (Morley and Karr 2002; Meador and Goldstein 2003; Alberti et al. 2003). These protections may be associated with critical area buffers, clearing limits, clustering development, and/or requiring shared roads.
- Limit the proximity of development to bluff-tops. In order to limit bluff saturation, require stormwater and septic systems to be piped away from bluffs, and require periodic maintenance to avoid leaks (Shipman 2001).
- Engage community through education and stewardship programs that recognize the unique role of adjacent private property owners in rehabilitating, maintaining, or degrading stream health (Booth et al. 2004).

9.2 Recommendations to Maintain Water Quality

In addition to the above recommendations, which will limit the concentration of surface flows, thereby improving water quality filtration, the following recommendations will help to limit the potential effects of development on water quality.

- Limit total area of roads and impervious surfaces, and maximize the distance of roads and septic systems from aquatic resource areas to limit the transport of pollutants, metals and pathogens to aquatic systems (Feist et al. 2011, Verstraeten et al. 2006). Limit channelization and routing of stormwater directly to receiving waters (Sorrano et al. 1996).
- Additional riparian standards in watersheds with significant agricultural or urban development may be warranted to effectively limit sediment and nutrient contributions from those land uses (Allan et al. 1997, Poor and McDonnel 2007).
- Avoid development encroaching on headwater streams and their riparian areas in order to maintain key nutrient filtration capacity (Alexander et al. 2007).
- Consider the effect of soils and slopes in developing effective buffer widths for sediment and nutrient filtration. Clay soils and steeper slopes require additional width for effective filtration of sediment (Figure 3, Dosskey et al. 2008). Infiltration, which is dependent on soil type and slopes, is the predominant determinant of the effectiveness of buffers in nutrient retention (Mayer et al. 2007). Determination of appropriate regulatory

buffers for sediment and nutrients could be made at a broad-scale (e.g., soil class) or based on actual site conditions.

- Wider buffers (30-120 m or 98-394 ft) are needed to filter fine sediment than may be indicated by total sediment retention percentages (Wenger 1999).
- Relatively narrow buffers (6-18 m or 20-59 ft) can effectively limit the transport of herbicides and pesticides through drift and runoff (Zhang et al. 2010).
- Best management practices for erosion control, herbicides and pesticide application, wastewater treatment, and nutrient management can help limit pollutant loading in riparian zones, making water quality functions of riparian zones more effective (Mayer et al. 2005, Reichenberger et al. 2007).
- Continue to monitor water quality conditions to identify and address primary sources of point-source and non-point-source pollutants.

9.3 Recommendations to Maintain Freshwater Habitats

- Conserve vegetated areas around headwater streams to maintain downstream temperatures (Elliot 2003, Cristea and Janisch 200), allochthonous input, invertebrates, (Wipfli 2005; Wipfli and Gregovich 2002, Wipfli et al. 2007) and detritus (Gomi et al. 2002) contributions, and important amphibian habitat (Sheridan and Olson 2003, Stoddard and Hayes 2005, Olson et al. 2007, Welsch & Hodgson 2008). Although riparian zones are more effective at improving water quality in headwater streams, broader riparian zones may be warranted to maintain habitat connectivity for amphibians.
- Recognize the significance of multiple scales of development on stream conditions. Physical stream attributes are most closely correlated with catchment-scale land cover, land cover within 500 m (1,640 ft) of the site, and the proximity to the nearest road crossing (McBride and Booth 2005). Riparian buffers are less closely correlated with stream structure than the above-listed landscape scale considerations. Nevertheless, buffers can effectively mediate physical stream attributes in rural watersheds, but the changes to hydrologic processes in urbanized watersheds may outweigh the effect of buffers in more highly developed areas (Segura and Booth 2010).

- In order to protect most wood recruitment functions, protect forest cover within one site-potential-tree-height (SPTH) or 30 m (98 ft) of a stream (Murphy and Koski 1989, McDade et al. 1990, Van Sickle and Gregory 1990, Robison and Beschta 1990). Additional widths should be considered to retain the full suite of wood recruitment based on windthrow effects (Reid and Hilton 1998). At a minimum, protecting large woody debris recruitment within the 15 m (49 ft) proximate to a stream will maintain the majority trees likely to enter the stream channel (Grizzel et al. 2000); however, because the upslope trees are removed, the likelihood of recruitment of those trees would be reduced.
- Ten-meter-wide riparian buffers are not sufficient to maintain invertebrate community composition (Kiffney et al. 2003, Hoover et al. 2007) or stream temperatures (Gomi et al. 2006). Thirty-meter-wide riparian buffers are generally sufficient to maintain sensitive invertebrate communities (Kiffney and Richardson 2003, 2004), and riparian width is not a significant factor in stream temperature beyond 30 m (98 ft) (Sridhar et al. 2004).
- Leaf cover and tree height are key correlates for maintaining water temperatures (Sridhar et al. 2004).
- Extensive buffers widths are needed to maintain pre-existing microclimate conditions (Chen et al. 1995, Dong et al. 1998, Heithecker and Halperin 2007); however, riparian areas ranging from 10-45 m (33-147 ft) will minimize microclimate edge effects (Brosofske et al. 1997, Heithecker and Halperin 2007).
- Protect forest stands, native shrubs, and large trees near open water for nesting habitat for sensitive birds and to maintain allochthonous contributions and food web linkages (Francis and Schindler 2006, Francis et al. 2007, Francis and Schindler 2009).
- Because ditched channels have the potential to support native fish communities, including salmonids (Colvin et al. 2009), establish best management practices or ensure that existing best management practices are followed in ditch-maintenance activities to maintain or enhance fish habitat and water quality within the channels.
- Monitor species and habitats to better track populations and landscape trends.

9.4 Recommendations to Maintain Marine and Estuarine Habitats

- Protect marine and estuarine habitats from the indirect effects of upland development by managing sediment, nutrients, metals, and pathogens in freshwater systems (Sections 3 and 4). Additionally, conserving allochthonous production and large woody debris recruitment in freshwater systems will maintain food web connections (Howe 2012) and sources of estuarine habitat diversity (MacLennan 2005, Hood 2007) (Section 5).
- Protect nearshore sediment transport processes by limiting development at the top of unstable bluffs and/or focusing developed areas on the landward portion of existing bluff-top lots. In particular, those bluffs identified as exceptional feeder bluffs (Johannessen and Chase 2005) warrant additional protection.
- Where development is permitted above feeder bluffs, management should focus on measures to maintain the natural hydrology by collecting runoff in drains and routing stormwater over the face of the bluff via pipes, locating septic systems away from the bluff, and ensuring that drainage systems remain in good repair (Shipman 2001, 2004). Soils and vegetation contributing to slope stability should be maintained (Shipman 2001, 2004).
- Monitor species and habitats to better track populations and landscape trends.
- Ensure data on species occurrence and habitats is the most up-to-date and current so that key habitats receive the protections under adopted ordinance.

9.5 Recommendations to Maintain Terrestrial Habitats

The existing Island County Code incorporates some protection of habitat connectivity, primarily through its stream and wetland buffer standards (ICC 17.02.050 (C)(3) and 17.02.050(A)(4). The Code also calls for avoidance of naturally vegetated corridors by utilities and public transportation projects (17.02A.050(C)(3)). Explicit protection of corridors is not otherwise included in the existing Code, although it is addressed at the policy level for the Parks Element (Island County Comprehensive Plan, 2011).

General recommendations for terrestrial habitats are listed in Section 9.5.1. Where species-specific recommendations are available for Washington State from WDFW guidance documents, these are summarized in Section 9.5.2.

9.5.1 General Terrestrial Habitat Management Recommendations

- Generally, plan development to minimize fragmentation of native habitat, particularly large, intact habitat areas. Where large forest stands exist, manage for forest-interior species and avoid fragmentation (Donnelly and Marzluff 2004, Diffendorfer 1995, Mason et al. 2007, Orrock and Danielson 2005, Pardini et al. 2005 and others). Clustering development, limiting clearing allowances, and setting platting limits can help limit fragmentation that can result from vegetation clearing or from roads.
- Manage to preserve scarce and rare habitats, such as prairies and old-growth forest, in the County. Given regional conservation priorities, prairies and their associated flora and fauna should be considered for designation as a Habitat of Local Importance (Floberg et al, 2004, WDFW, 2005).
- Manage agricultural development to limit fragmentation and edge; preserve vegetative structural diversity whenever possible in agricultural areas by retaining areas of native vegetation (Southerland 1993).
- Control invasive species where needed on a site- and species-specific basis. Address invasive species specifically in areas where environmental conditions tend to promote infestation, including created edges, roadways, riparian zones contiguous with developed areas, and sources of materials (e.g., gravel, compost, etc.) (Olden et al. 2004, Pimentel et al. 2005, McKinney 2002 and others).
- Maintain or provide habitat connectivity with vegetated corridors between habitat patches (Schaefer 2003, Clair 2008, Gilbert-Norton et al. 2010 and others). This may include limiting new road corridors, limiting clearing, clustering development, or providing wildlife passage on larger roads. Habitat connectivity can be provided through native vegetated corridors, although hedgerows can also provide shelter and nesting

habitat for small mammals, insects, pollinators, spiders, birds and reptiles. More information on hedgerows is available online[18].

- Protect, maintain, and promote habitat features such as snags and downed wood (Blewett and Marzluff 2005).
- Manage for increased native vegetative cover in landscaping and discourage lawns (Nelson and Nelson 2001).
- Plan habitat areas away from roads (Fahrig et al. 1999, Lehtinen et al. 1999).
- Promote buffers of adequate width to support wildlife guilds in adjacent habitat (Ficetola et al. 2008, Semlitsch and Bodie 2003, Crawford and Semlitsch 2006).
- Preserve habitat patches of at least moderate size 35 ha (86 ac) within developed areas (Kissling and Garton 2008).
- Monitor species and habitats to better track populations and landscape trends.

9.5.2 WDFW Species-specific Management Recommendations

American White Pelican

WDFW management recommendations for non-breeding white pelicans focus on protection of feeding and loafing areas (Doran et al. 1998). Recommendations are to identify and survey foraging areas to determine prey presence and abundance, and to maintain and manage these areas for prey base fish species. Specifically, maintaining shallow water (0.3 to 2.5 m; 1.0 to 8.3 feet) and deeper waters where depth fluctuations occur is recommended. Maintaining abundant fish populations is also recommended in a diversity of water bodies, including rivers, sloughs, and marshes. Finally, limiting disturbance from hunting, fishing, boating, and other recreational activities at foraging sites is recommended.

Bald Eagle

Bald eagles are likely to be detrimentally impacted by activities that alter nest, roost, or perch trees; removal of adequate buffers; noise and other human disturbance; and potentially decreasing salmon runs (Watson and Rodrick 2000).

[18] http://www.piercecountycd.org/tip_hedge_p.html
http://nativeplantwildlifegarden.com/hedgerows/

WDFW recommendations focus on retaining buffers, from different activities, as shown in Table 3. Nest protections need to be in place year-round, as bald eagles typically reuse nests from year to year, skipping years or moving to alternate nests on occasion. Exact activities and protections within each zone may vary by site, but generally should include retention of large trees and restriction of most construction (Protected Zone), and protection of alternate nest locations, perch trees, and foraging sites and avoidance of construction use activities that are not low-impact (Conditioned Zone). Non-nesting protections include retaining and protecting perch trees and buffering foraging sites from disturbance.

Table 3. Bald eagle recommended buffers from Watson and Rodrick 2000.

Nesting	Protected Zone	120 m (400 ft)
	Conditioned Zone	100-240 m (330-800 ft) beyond Protection Zone
Roosting	Timber Harvest Zone	100 m (400 ft)
	Human Disturbance Zone	100 m (400 ft)
Perching and Foraging	Perch Protection	Protect perches within 75 m (246 ft) of top-of-bank or shoreline
	Human Disturbance and Structures	450 m (1,500 ft)

Common Loon

Common loon protection recommendations are aimed primarily at breeding habitat (Lewis et al. 1999). General recommendations are to protect known nest and nursery sites from disturbance, avoid structures near nest sites, and provide artificial nesting islands where appropriate. Because loons are not known or expected to nest in Island County, nesting recommendations are generally not applicable to the County. Specific recommended buffers are in Table 4.

Table 4. Common loon recommended buffers from Lewis et al. 1999.

Activity	**Buffer width**	**Buffer from**	**Timing**
Construction	150 m (490 ft)	Nest site	Year-round
All human activities		Nest site	15 April-15 July
All human activities		Nursery	15 July-1 September

Great Blue Heron

WDFW recommends protection mechanisms for Heron Management Areas, which consist of the nesting colony, year-round and seasonal buffers, foraging habitat, and congregation areas where they exist (Azerrad 2012). Specifically, clearing vegetation, grading, and construction should never occur in the core zone, and other potential disturbances, including recreation and vegetation management, should be minimized or restricted to the period outside of the breeding season. Foraging habitat should be protected with riparian buffers, as well as wetland and shoreline habitat protection, particularly in the period between March and September. Activities such as vegetation removal, logging, perch tree disturbance, wetland filling, and construction should be minimized. A specific watercraft use buffer of 180 m (590 feet) from shallow foraging waters is recommended. Heron colonies closer to human activity may tolerate more disturbance than colonies in more undisturbed areas; therefore, appropriate buffers may be smaller in more developed areas. Year-round and seasonal buffer recommendations are provided in Table 5. Azerrad (2012) also recommends protecting alternate nesting stands

Table 5. Great blue heron recommended buffers from Azerrad 2012.

Year-round Buffers	
Undeveloped	300 m(984 ft)
Suburban/rural	200 m (656 ft)
Urban	60 m (196 ft)
Seasonal Buffers (February-September)	
Loud noises	200 m (656 ft)
Extreme loud noises like blasting	400 m (1320 ft)

Peregrine Falcon

General WDFW management recommendations for the species include routing powerlines away from nests, protecting wetlands used by peregrine falcons, restricting pesticide use in winter foraging areas and near nests during the breeding season, maintaining large trees and snags in winter feeding areas, and retaining snags and debris on mud flats (Hays and Milner 1999). Buffer recommended for specific activities are shown in Table 6.

Table 6. Peregrine falcon recommended buffers from Hays and Milner 1999.

Activity	Buffer width	Buffer from	Timing
Human access to cliffs	800 m (2620 ft)	Cliff nest	March-late June
Human activities on or below cliffs	400-800 m (1310-2620 ft)	Cliff nest	March-late June
Recreation (trails/picnic area) development	400-800 m (1310-2620 ft)	Cliff nest	Year-round
All development	NA	Cliff nest	Year-round
Forest practices (review rules)	400 m (1310 feet)	Any nest	Year-round
	800 m (2620 ft)		March 1-June 30
Aircraft approaches	500 m (1640 ft)	Any nest	March 1-June 30

Pileated Woodpecker

WDFW management recommendations for pileated woodpecker specific to western Washington are aimed at forest stand features and protection strategies within home ranges rather than creation of buffers for individual nest sites. Maintaining snags and decaying live trees within home ranges for nesting and roosting, retaining snags and downed wood for foraging, using average snag-retention recommendations (rather than minimums), and creating snags in older secondary forest are general strategies (Lewis and Azerrad 2003 with January 2005 updates). In western Washington, home range size is on average 600 ha (1480 ac), west of the Cascades and about 850 ha (2100 ac) on the Olympic peninsula. Maintenance of coniferous forest of about 60 years or more in age at 70% canopy cover is recommended overall. Snag retention recommendations are given in Table 7.

Table 7. Snag retention recommendations for pileated woodpecker (from Lewis and Azerrad 2003 with January 2005 updates).

Habitat component focus	Size class (dbh)	Snags to retain (per ac)
Nesting and roosting	≥76 cm (≥30 in)	≥0.2
	155-310 cm (61-122 in)	≥7
Foraging	25-50 cm (10-20 in)	≥12
	50-76 cm (20-30 in)	≥12
	≥76 cm (≥30 in)	≥12

9.6 Species of Local Importance

The existing County Code allows for any person to nominate a species or habitat for designation as a Species or Habitat of Local Importance (ICC 17.02.050(C)(1)(h)). Nominated species must satisfy the following criteria:

1. Local populations which are in danger of extirpation based on existing trends since January 1, 1985.

2. The species is sensitive to habitat manipulation.

3. The species or habitat has commercial, game, or other special value such as locally rare species.

Habitats nominated to protect a particular species must satisfy the following criteria:

1. Where a habitat is nominated to protect a species, the use of the habitat by that species is documented or is highly likely or the habitat is proposed to be restored with the consent of the affected property owner so that it will be suitable for use by the species; and

2. Long term persistence of the species is dependent on the protection, maintenance or restoration of the habitat.

Areas nominated for protection must represent either high quality native habitat or habitat that has an excellent potential to recover to a high quality condition and that is either of limited availability or highly vulnerable to alteration.

Appendix A includes a list of species and habitats identified by WDFW, DNR, and The Nature Conservancy's Ecoregional Assessment as priority species and habitats in the State that occur in Island County. WDFW's Wildlife Conservation Strategy (electronic reference) was also consulted to identify species of greatest conservation concern. In addition to those species identified on the WDFW list, the PHS-designated Western Washington breeding concentrations of cormorants, storm-petrels, terns, and alcids are also significant within Island County since numerous breeding colonies of pigeon guillemots occur there as shown on Map 4 (Milner, R., WDFW, personal communication, December 16, 2013).

Species not included on the WDFW or DNR lists may also be vulnerable, if they represent local, isolated populations. For example, it was recently discovered that the Puget Sound population of the seaside juniper is genetically distinct from other populations, and it constitutes a separate species (Adams 2007). On Whidbey Island, a natural population of 10-20 trees was found on coastal sand dunes in Deception Pass Park (near Cranberry Lake). The site is protected in park ownership; however, beach use or a large storm could threaten this population (Adams 2007). Several other seaside junipers appear to have been planted at houses in the interior of Whidbey Island and are growing well in deep soil (Adams 2007).

Species and habitats listed in Appendix A, and shown on Map 4 likely warrant further monitoring and conservation attention.

9.7 General Buffer Considerations

A variable-width riparian zone is one policy approach that can be used to manage the effects of landscape or site-specific factors. Through this approach, the width of the prescribed riparian zone may change depending on factors like hillslope, soil type, landscape position, or surrounding development. While this approach may provide greater flexibility than a fixed-width riparian zone approach for achieving effective riparian function, it may necessitate costly analysis of individual property characteristics and increased regulatory staff time. If fixed-width buffers are implemented, however, conservative (larger) buffer widths are recommended in order to ensure that riparian buffers are effective under a range of variable conditions.

Primarily focused on best management practices for agriculture and forest practices, the Field Office Technical Guide for Island County (NRCS, electronic reference) provides site planning tools, including calculations for estimating soil erosion, managing plants for pollinators, and providing habitat for wildlife and birds. This technical guide could be used in developing site-specific standards for soil conservation and best management practices associated with soil disturbance. Property owners may choose to voluntarily implement NRCS planning in order to take advantage of available cost share funding through NRCS and WSCC.

Buffer averaging provides one approach to provide limited flexibility that can be associated with variable- or fixed-width buffers. Buffer averaging allows for limited reductions in riparian zone width so long as they are offset by wider riparian zones in adjacent areas. This type of approach can be particularly effective if implemented such that the wider buffer areas are located in existing depressions or swales where surface runoff is likely to become channelized. These approaches to balance land use and ecological needs present potential benefits, but ecosystem tradeoffs and cumulative effects should be carefully weighed if these alternative approaches are considered.

Another buffer approach that may be considered is a tiered approach to riparian protection, similar to the approach used in forestry management (WAC 222). This tiered approach offers the greatest protection (i.e. no touch) for the area closest to the stream and allows some selective harvest moving away from the stream. This may be a management option to allow ensure that the key functions are maintained adjacent to the stream channel, and to maintain some of the functions associated with wider distances (e.g., micro-climate and wildlife habitat).

Where development is proposed on properties with habitats that are presently degraded, active restoration and maintenance (e.g., revegetation with appropriate native species, instream enhancements) is recommended to regain some of those lost functions. Some functions (*i.e.*, sediment, nutrient, and pesticide retention) will be restored quickly, while others (*e.g.*, stream bank stability, temperature regulation, LWD recruitment, and forest habitats) will improve slowly as the riparian zone matures. In the interim period, restoration actions like the placement of LWD habitat structures, following best management practices, and decommissioning roads may help limit land use impacts and improve habitat functions.

10 REFERENCES

Abu-Zreig, M., R.P. Rudra, M.N. Lalonde, H.R. Whiteley, and N.K. Kaushik. 2004. Experimental Investigation of Runoff Reduction and Sediment Removal by Vegetated Filter Strips. Hydrological Processes. 18: 2029-2037. Published online 12 May 2004 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.1400.

Adams, L.W. 1994. Urban Wildlife Habitats: A Landscape Perspective. Univ. of Minn. Press, Minneapolis, MN. 208pp.

Adams, R.P. 2007. *Juniperus Maritima*, the Seaside Juniper, a New Species from Puget Sound, North America. *Phytologia* 89 (3): 263–283.

Adamus, P. 2006. Wetlands of Island County, Washington. Profile of Characteristics, Functions, and Health. August 2006.

Adamus, P. 2007. Best Available Science for Wetlands of Island County, Washington: Review of Published Literature. A Report Prepared in Response to Critical Areas Ordinance Updating Requirements for Wetlands.

Alberti M, D. Booth, K. Hill, B. Coburn, C. Avolio, S. Coe, and D. Spirandelli. 2007. The impact of urban patterns on aquatic ecosystems: an empirical analysis in Puget lowland sub-basins. Landscape Urban Planning 80(4):345-61.

Alexander R.B., E.W. Boyer, R.A. Smith, et al. 2007. The role of headwater streams in downstream water quality. *Journal of Am. Water Resour*. 43:41–59.

Alexander, LL. 1991. Patterns of mortality among common loons wintering in the northeastern gulf of Mexico. *Fla. Field Nat*. 19: 73-79

Allan, J. D., D. L. Erickson, and J. Fay. 1997. The influence of catchment land use on stream integrity across multiple spatial scales. *Freshwater Biol*, 37(1), 149-161.

Allan, J.D., M.S. Wipfli, J.P. Caouette, A. Prussian, J. Rodgers. 2003. Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs. *Canadian Journal of Fisheries and Aquatic Sciences*. 60(3): 309-320.

Andersen, L.W., K. Fog, and C. Damgaard. 2004. Habitat fragmentation causes bottlenecks and inbreeding in the European tree frog (*Hyla arborea*). Proceedings. Biological Sciences / The Royal Society 271 :1293–302.

Anderson, D.M., P.M. Glibert, J.M. Burkholder. 2002. Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences. Estuaries 25(4b)704:726.

Arens, P., T. Sluis, W.P.C. van't Westende, B. Vosman, C.C. Vos, and M.J.M. Smulders. 2007. Genetic Population Differentiation and Connectivity Among Fragmented Moor Frog (*Rana Arvalis*) Populations in the Netherlands. *Landscape Ecology* 22 (10): 1489–1500.

Arnett, J. 2013. *Castilleja levisecta* Global Population Estimates. Prepared by Joe Arnett, November 19, 2013.

Arnold, Jr., C.L. and C.J. Gibbons. 1996. Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62(2): 243-258.

Aubry, K., C. Halpern, and C.Peterson. 2009. Variable-retention harvests in the Pacific northwest: a review of short-term findings from the DEMO study. *For Ecol Manage* 258(4):398-408.

Ayres, K.L., R.K. Booth, J.A. Hempelmann, K.L. Koski, C.K. Emmons, et al. 2012. Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (*Orcinus orca*) Population.

Azerrad, J.M. 2012. Management Recommendations for Washington's Priority Habitats and Species: Great Blue Heron (*Ardea herodias*). 3-1 to 3-18 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Azous, A. L. and R.R. Horner. 1997. Wetlands and urbanization: Implications for the Future. Final Report of the Puget Sound Wetlands and Stormwater Management Research Program. Washington State Department of Ecology; King County Water and Land Resources Division; and University of Washington.

Baker M.E., D.E. Weller, and T.E. Jordan. 2006. Improved methods for quantifying potential nutrient interception by riparian buffers. *Landscape Ecol* 21(8):1327-45.

Ball, J., Bauer, RD., Vermeer, K., & Rabenberg, M.J. 1989. Northwest riverine and Pacific coast. In: Smith, L.M., Pederson, R.L. & Kaminski, R.M.(Eds.). Habitat Management for Migrating and Wintering Waterfowl in North America. Texas Tech University Press, Lubbock, Texas. Pp. 429-44.

Bargmann, G. 1998. Forage Fish Management Plan: A plan for managing the forage fish resources and fisheries of Washington. Washington Department of Fish and Wildlife. Olympia, WA.

Beamer, E. 2007. Juvenile salmon and nearshore fish use in shoreline and lagoon habitat associated with Ala Spit, 2007. December 2007.

Beamer, E., A. McBride, R. Henderson, and K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: An emerging priority for restoration.

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: linking estuary restoration to wild Chinook salmon populations. Appendix to the Skagit Chinook Recovery Plan. Available at www.skagitcoop.org/.

Beamer, E., A. McBride, R. Henderson, J. Griffith, K. Fresh, T. Zackey, R. Barsh, T. Wyllie-Echeverria, and K. Wolf. 2006a. Habitat and fish use of pocket estuaries in the Whidbey Basin and north Skagit County bays, 2004 and 2005. Skagit River System Cooperative, La Conner, WA.

Beamer, E., A. Kagley, and K. Fresh. 2006b. Juvenile salmon and nearshore fish use in shallow intertidal habitat associated with Harrington Lagoon, 2005.

Beamer, E., B. Brown, and K. Wolf. 2012. Juvenile salmon and nearshore fish use in shallow intertidal habitat associated with Dugualla Heights Lagoon, 2012. Prepared for Whidbey Camano Land Trust.

Beamer, E., T. Zackey, D. Marks, D. Teel, D. Kuligowski and R. Henderson. 2013. Juvenile Chinook Salmon Rearing in Small Non-Natal Streams Draining into the Whidbey Basin. SRSC. December 3, 2013.

Becker, C.G., C.R. Fonseca, C.F.B. Haddad, R.F. Batista, and P.I. Prado. 2007. Habitat split and the global decline of amphibians. Science 318:1775-1777

Beeson, C. and P. Doyle. 1995. Comparison of Bank Erosion and Vegetated and Non-Vegetated Channel Bends. *Journal of American Water Resources Association* 31(6)983-990.

Beier, P. and R.F. Noss. 1998. Do habitat corridors provide connectivity? *Conserv. Bio*. 12:1241-1252

Belisle, M., A. Desrochers, and M.J. Fortin. 2001. Influence of forest cover on the movements of forest birds: a homing experiment. Ecology, 82(7):1893–1904.

Bender, D., T. Contheran, and L. Fahrig. 1998. Habitat loss and population decline: A meta-analysis of the patch size effect. Ecology, 79(2):517–533.

Bernal, S., F. Sabater, A. Butturini, E. Nin, and S. Sabater. 2007. Factors limiting denitrification in a Mediterranean riparian forest. Soil Biology & Biochemistry 39 (10): 2685-2688.

Beschta, R. L., Bilby, R. E., Brown, G. W., Holtby, L. B., and Hofstra, T. D. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. Pages 191-232 *in* E. O. Salo, and T. W. Cundy, editors. Streamside management: Forestry and Fishery Interactions. University of Washington, Seattle, WA.

Bettesworth, J. 2014. Northern Harriers – Whidbey Island 1994 through 2006: A brief report on productivity and nesting/hunting areas. Birds of North America Online, http://www.birds.cornell.edu/bfl/speciesaccts/olsfly.html. January 2014.

BirdWeb (Seattle Audubon Society) – table of designations from the federal List of Threatened and Endangered Species, the Audubon/American Bird Conservancy Watch List, the state Species of Concern List, and the Audubon Washington Vulnerable Birds list. [http://birdweb.org/birdweb/specialconcern]

Bilby, R.E., and P.A. Bisson. 1998. Function and distribution of large woody debris. In R.J. Naiman and R.E. Bilby [eds.], Ecology and Management of Rivers. Springer-Verlag, New York.

Bisson, P. A., S.M. Claeson, S.M. Wondzell, A.D. Foster, and A. Steel. 2013. Evaluating Headwater Stream Buffers: Lessons Learned from Watershed- scale Experiments in Southwest Washington. Pgs. 165-184 In: Anderson, P. D. and Ronnenberg, K.

L. (eds.). Density Management in the 21st Century: West Side Story. General Technical Report, PNW-GTR-880. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Bisson, P.A., J.B. Dunham, G.H. Reeves. 2009. Freshwater Ecosystems and Resilience of Pacific Salmonid Habitat Management Based on Natural Variability. Ecology and Society 14(1)45.

Blair, R. 1996. Land use and avian species diversity along an urban gradient. *Ecol. Appl*. 6:506-519.

Blanco-Canqui, H., C.J. Gantzer, S.H. Anderson, and E.E. Alberts. 2004. Grass barriers for reduced concentrated flow induced soil and nutrient loss. *Soil Science Society of America Journal* 68:1963-1972.

Blewett, C.M. and J.M. Marzluff. 2005. Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds. *Condor* 107:677-692.

Bolton, S. and J. Shellberg. 2001. Ecological Issues in Floodplains and Riparian Corridors. Report to Washington Dept. of Transportation, Olympia.

Booth, D. 1990. Stream channel incision following drainage-basin urbanization. *JAWRA Journal of the American Water Resources* 26 (3): 407–417.

Booth, D. 2000. Forest cover, impervious surface area, and the mitigation of urbanization impacts in King County, Washington. Prepared for King County Water and Land Resources Division.

Booth, D.B., and P.C. Henshaw. 2001. Rates of channel erosion in small urban streams. Pages 17-38 in M.S. Wigmosta and S.J. Burges, editors. Land Use and Watersheds: human influences on hydrology and geomorphology in urban and forestry areas. Water and Science Application Volume 2. Amer. Geophysical Union, Washington, DC.

Booth, D.B. and C.R. Jackson. 1997. Urbanization of aquatic systems-degradation thresholds, stormwater detention, and the limits of mitigation. *Journal of American Water Resources Association* 22:

Booth, D.B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. *Journal of American Water Resources Association* 38:835-845.

Booth, D. B., J. R. Karr, S. Schauman, C. P. Konrad, S. A. Morley, M. G. Larson, and S. J. Burges. 2004. Reviving urban streams: land use, hydrology, biology, and human behavior. *Journal of the American Water Resources Association*, 40:1351-1364.

Boyd, R. 1999. Indians, Fire, and the Land in the Pacific Northwest. Oregon State University Press, Corvallis, Oregon. 1999.

Bragg, DC. 2000. Simulating Catastrophic and Individualistic Large Woody Debris Recruitment for a Small Riparian System. Ecology 81(5):1383-1394.

Brazier, J. R., and G.W. Brown, G. W. 1973. Buffer strips for stream temperature control. Forest Research Laboratory, School of Forestry, Oregon State University, Corvallis, OR.

Brennan, J.S. and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program, Copyright 2005, UW Board of Regents. Seattle, Washington. 34 pp.

Briggs, K. T., W. B. Tyler, D. B. Lewis, P. R. Kelly, and D. A. Croll. 1983. Brown Pelicans in central and northern California. J. Field Ornithol. 54:353-373.

Brooks, M. L.,C.M. D’Antonio, D.M. Richardson, J.B. Grace, J.E. Keeley, J.M. DiTomaso, D. Pyke. 2004. Effects of Invasive Alien Plants on Fire Regimes. BioScience, 54(7), 677.

Brosofske, K.D., J.Q Chen, R.J. Naiman, and J.F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in Western Washington. Ecological Applications 7: 1188-1200.

Brown, B. and R. Mitchell. 2001. Competition for pollination: effects of pollen of an invasive plant on seed set of a native congener. Oecologia, 129(1), 43–49.

Brown, B. J., R.J. Mitchell, and S.A. Graham. 2002. Competition for pollination between an invasive species (Purple loosestrife) and a native congener. Ecology, 83(8), 2328–2336.

Brown, G.W. and J.T. Kryger. 1970. Effects of clear-cutting on stream temperature. Water Resources Research 6:1122-1139.

Burger A. 1995. Inland habitat associations of marbled murrelets in British Columbia. Ralph CJ, Hunt GLJ, Raphael MG, and others(eds.).

Burges, S. J., M. S. Wigmosta, and J.M. Meena. 1998. Hydrological effects of land-use change in a zero-order catchment. Journal of Hydrologic Engineering.

Burgess, N.M. and M.W. Meyer. Methylmercury exposure associated with reduced productivity in common loons. Ecotoxicology. 2008:17:83–91.

Bustard, D.R., and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada. 32: 667-680.

Buzzelli, C., A. F. Holland, D.M. Sanger and P.C. Conrads. 2007. Hydrographic Characterization of Two Tidal creeks with Implications for Watershed Land Use, Flushing Times and Benthic Production. Estuaries and Coasts. Vol. 30, No. 2:321-330.

Calambokidis, J. et al. 1984. Chemical Contaminants in Marine Mammals from Washington State. NOAA Tech. Memo. NOS OMS 6.

Calambokidis, J. et al. 1985. Biology of Puget Sound Marine Mammals and Marine Birds: Population Health and Evidence of Pollution Effects. NOAA Tech. Memo. NOS OMA 18.

Caliman, F.A. and M. Gavrilescu. 2009. Pharmaceuticals, personal care products and endocrine disrupting agents in the environment - a review. Clean Soil, Air, Water 37:4-5.

Chappell, C.B. 2006. Upland plant associations of the Puget Trough ecoregion, Washington. Natural Heritage Rep. 2006-01. Washington Department of Natural Resources, Natural Heritage Program, Olympia, Wash. [http://www1.dnr.wa.gov/nhp/refdesk/communities/pdf/intro.pdf].

Colvin, R., G.R. Giannico, J. Li, K.L. Boyer, and W.J. Gerth. 2009. Fish use of intermittent watercourses draining agricultural lands in the upper Willamette River Valley, Oregon. Trans. Am. Fish. Soc. 138: 1303-1313.

Crawford, J.A. and R.D. Semlitsch. 2007. Estimation of Core Terrestrial Habitat for Stream-Breeding Salamanders and Delineation of Riparian Buffers for Protection of Biodiversity. Conserv. Biol. 21:152-158

Crosby, M.K.A., L.E. Licht, and J. Fu. 2008. The effect of habitat fragmentation on finescale population structure of wood frogs (*Rana sylvatica*). Conservation Genetics 10(6):1707–1718.

Cristea, N. and J. Janisch. 2007. Modeling the effects of riparian buffer width on effective shade and stream temperature. Publication No. 07-03-028. Washington Department of Ecology.

Cuo, L., D.P. Lettenmaier, M. Alberti, and J.E. Richey. 2009. Effects of a century of land cover and climate change on the hydrology of the Puget sound basin. Hydrol Process 23(6):907-33.

Cushman, S. A. 2006. Effects of habitat loss and fragmentation on amphibians: A review and prospectus. Biological Conservation, 128(2), 231–240.

Daehler, C. C. 2003. Performance comparisons of co-occurring native and alien invasive plants: Implications for conservation and restoration. Annual Review of Ecology, Evolution, and Systematics, 34(1), 183–211.

Dale, V. H., S. Brown, R. A. Hauber, N. T. Hobbs, N. Huntly, R. J. Naiman, W. E. Riebsame, M. G. Turner, and T. J. Valone. 2000. Ecological Principles and guidelines for managing the use of land. Ecological Applications 10: 639-670.

Daub, B.C. 1989. Behavior of common loons in winter. J Field Ornithol 60: 305–311.

DeGasperi C., H. Berge, K. Whiting, J. Burkey, J. Cassin, R. Fuerstenberg. 2009. Linking hydrologic alteration to biological impairment in urbanizing streams of the Puget lowland, Washington, USA. J Am Water Resour Assoc. 45(2):512-33.

Delaney, K.S., S.P.D. Riley, and R.N. Fisher. 2010. A rapid, strong, and convergent genetic response to urban habitat fragmentation in four divergent and widespread vertebrates. Edited by Robert C. Fleischer. PloS One 5 (9): 11.

Delong, M.D. and M.A. Brusven. 1998. Macroinvertebrate Community Structure along the Longitudinal Gradient of an Agriculturally Impacted Stream. Environmental Management-Springer-Verlag.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone - A summary review and bibliography. Coastal Resources Center Technical Report No. 2064. University of Rhode Island Graduate School of Oceanography. Narragansett, RI 02882. 72 p.

Desrochers, A. and S. J. Hannon. 1997. Gap crossing decisions by dispersing songbirds during the post-fledging period. Conserv. Biol. 11:1204-1210.

Dethier, M. 2006. Native Shellfish in Nearshore Ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2006-04. Seattle District, U.S. Army Corps of Engineers, Seattle, WA.

Dieterich, M. and N.H. Anderson. 1998. Dynamics of abiotic parameters, solute removal and sediment retention in summer-dry headwater streams of western Oregon. Hydrobiologia 379: 1-15.

Diffendorfer, J. E., M.S. Gaines, and R.D. Holt. 1995. Habitat Fragmentation and Movements of Three Small Mammals (Sigmodon, Microtus, and Peromyscus). Ecology 76(3), 827.

Dixo, M., J.P. Metzger, J.S. Morgante, and K.R. Zamudio. 2009. Habitat fragmentation reduces genetic diversity and connectivity among toad populations in the Brazilian Atlantic coastal forest. Biological Conservation 142(8):1560–1569.

Dong, J., J. Chen, K.D. Brosofske, and R.J. Naiman. 1998. Modelling air temperature gradients across managed small streams in western Washington. Journal of Environmental Management 5:309-321.

Doran, P.J., M. Whalen, K. Riener, and L. Fitzner. 1998. American White pelican. Pages 2-1 to 2-7 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington’s Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Dosskey, M.G., K.D. Hoagland, and J.R. Brandle. 2007. Change in filter strip performance over ten years. J Soil Water Conserv 62(1):21-32.

Dosskey, M. G., M. J. Helmers, and D. E. Eisenhauer. 2008. A design aid for determining width of filter strips. Journal of Soil and Water Conservation 63(4):232-241.

Dudley, S., J. C. Fischenich, and S. R. Abt. 1998. Effect of woody debris entrapment on flow resistance. J. Amer. Water Res. Assoc. 34(5): 1189-1197.

Eamer, J. and I. Walker. 2010. Quantifying sand storage capacity of large woody debris on beaches using LiDAR. Geomorphology 118(1-2)33-47.

Earth Sanctuary Ecological Design. 2005. 500 Year Ecological Management Plan Created for Chuck Pettis, Earth Sanctuary LLC by Kevin Fetherston, Seattle. 2002. Amended 2005.

Ebersole, J., W. Liss, and A. Frissell. 2003. Cold water patches in warm streams. Journal of the American Water Resources Association 39(2):355–368.

Fahrig, L., J.H. Pedlar, S.H. Hope, P.D. Taylor, and J.F. Wagner. 1995. Effects of road traffic on amphibian density. Biol. Conserv. 73:177-182.

Falcone, E., J. Calambokidis, G. Steiger, M. Malleson, and J. Ford. 2005. Humpback whales in the Puget Sound/Georgia Strait Region. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference.

Fausch, K. D., and T.G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49:682-693.

Federal Register. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Taylor's Checkerspot Butterfly and Threatened Status for the Streaked Horned Lark; Final Rule. 50 CFR Part 17. October 3, 2013.

Feist, B. E., E.R. Buhle, P. Arnold, J.W. Davis and N.L. Scholz. 2011. Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams. PLoS ONE 6(8):e23424.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. U.S. Departments of Agriculture, Commerce, and Interior. Portland Oregon.

Ficetola, G.F., E. Padoa-Schioppa, and F. DeBernardi. 2008. Influence of landscape elements in riparian buffers on the conservation of semi-aquatic amphibians. Conserv. Biol. 23:114-123.

Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007. North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Finlayson, D. 2006. The geomorphology of Puget Sound beaches. Puget Sound Nearshore Partnership Report No. 2006-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at http://pugetsoundnearshore.org.

Fleeger, J. W., K.R. Carman, and R.M. Nisbet. 2003. Indirect Effects of Contaminants in Aquatic Ecosystems. The Science of the Total Environment.

Ford, J. K. B. and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316:185-199.

Ford, T.B. and J.A. Gieg. 1995. Winter behavior of the common loon. J Field Ornithol 66: 22–29

Floberg, J., M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Iachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, D. Rolph. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. Prepared by The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

Francis, T.B. and D.E. Schindler. 2006. Degradation of littoral habitats by residential development: woody debris in lakes of the Pacific Northwest and Midwest, United States. Ambio, 35, 274–280.

Francis, T.B., D.E. Schindler, J.M. Fox, and E. Seminet-Reneau. 2007. Effects of urbanization on the dynamics of organic sediments in temperate lakes. Ecosystems.

Francis, T B. and D E. Schindler. 2009. Shoreline urbanization reduces terrestrial insect subsidies to fishes in North American lakes. Oikos 118(12):1872-1882.

Fresh, K., M. Dethier, C. Simenstad, M. Logsdon, H. Shipman, C. Tanner, T. Leschine, T. Mumford, G. Gelfenbaum, R. Shuman, J. Newton. 2011. Implications of Observed Anthropogenic Changes to the Nearshore Ecosystems in Puget Sound. Prepared for the Puget Sound Nearshore Ecosystem Restoration Project. Technical Report 2011-03.

Galbraith, R.V., E.A. MacIsaac, J. Macdonald, J. Stevenson, A.P. Farrell. 2006. The effect of suspended sediment on fertilization success in sockeye (Oncorhynchus nerka) and coho (Oncorhynchus kisutch) salmon. Canadian Journal of Fisheries & Aquatic Sciences.

Gilbert-Norton, L, R Wilson, JR Stevens, and KH Beard. 2010. A meta-analytic view of corridor effectiveness. Conserv. Biol. 24:660-668.

Gillies, C.S. and C.C. St. Clair. 2008. Riparian corridors enhance movement of a forest specialist in a fragmented tropical forest

Glasoe, S. and A. Christy. 2004. Literature Review and Analysis: Coastal Urbanization and Microbial Contamination of Shellfish Growing Areas. Puget Sound Action Team. Publication #: PSAT04-09

Gomi, T., R. D. Moore, and A.S. Dhakal. 2006. Headwater Stream Temperature Response to Clear-cut Harvesting with Different Riparian Treatments, Coastal British Columbia, Canada. Water Resources Research. Vol. 42, W08437, doi:10.1029/2005WR004162.

Gomi, T., D. Moore, and M. Hassan. 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. J Am Water Resour Assoc 41(4):877-98.

Gomi, T., R. Sidle, and J. Richardson. 2002. Understanding processes and downstream linkages of headwater systems. Bioscience 52(10):905-16.

Gonor, J.J., J.R. Sedell, and P.A. Benner. 1988. What we know about large trees in estuaries, in the sea, and on coastal beaches. In: From the forest to the sea, a story of fallen trees. Maser, C., R.F. Tarrant, J.M. Trappe, and J.F. Franklin, tech eds. USDA Forest Service General Technical Report. GTR-PNW-229, Pacific Northwest Research Station. Portland, OR, pp. 83-112.

Grant, S.C.H and P.S. Ross. 2002. Southern Resident Killer Whales at Risk: Toxic Chemicals in the British Columbia and Washington Environment. Canadian Technical Report of Fisheries and Aquatic Science 2412. Fisheries and Oceans Canada.

Gregory, S.V., F.J. Swanson, W. A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41: 540-551.

Grizzel, J., M. McGowan, D. Smith, and T. Beechie. 2000. Streamside buffers and large woody debris recruitment: evaluating the effectiveness of watershed analysis prescriptions in the North Cascades region. TFW-MAG1-00-003. Olympia, WA. Timber Fish and Wildlife 37p.

Gurnell, A.M., H. Piegay, F.J. Swanson, and S.V. Gregory. 2002. Large wood and fluvial processes. Freshwater Biology, 47(4), 601–619.

Hachmoller, B., R.A. Matthews, and D.F. Brakke. 1991. Effects of riparian community structure, sediment size, and water quality on the macroinvertebrate communities in a small, suburban stream. Northwest Science 65(3):125-132.

Hamer, T. and S. Nelson. 1995. Characteristics of marbled murrelet nest trees and nesting stands. USDA Forest Service Gen. Tech. Rep. PSW-152.

Haney, J.C. 1990. Winter habitat of common loons on the continental shelf of the southeastern United States. Wilson Bull 102: 253–263

Hannon, S.J. and F.K.A. Schmiegelow. 2002. Corridors may not improve the conservation value of small reserves for most boreal birds. Ecological Applications 12:1457–1468.

Hansen, A. J., R. L. Knight, J. M. Marzluff, S. Powell, K. Brown, P. H. Gude, and K. Jones. 2005. Effects of exurban development on biodiversity: patterns, mechanisms, and research needs. Ecological Applications 15:1893-1905.

Harding, J. S., K. Claassen, and N. Evers. 2006. Can forest fragments reset physical and water quality conditions in agricultural catchments and act as refugia for forest stream invertebrates? Hydrobiologia 568:391-402.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack Jr., and K.W. Cummins. 1986. Ecology of Coarse Woody Debris in Temperate Ecosystems. Advances in Ecological Research 15:133-301.

Hauxwell, J., J. Cebrián, I. Valiela. 2003. Eelgrass Zostera marina loss in temperate estuaries: relationship to land-derived nitrogen loads and effect of light limitation imposed by algae. Marine Ecology Progress Series 274:59-73.

Hays, D.W and R.L. Milner. 1999. Peregrine Falcon. Pages 11-1 to 11-4 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for

Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Hayes, M., S. Rubin, R. Reisenbichler, F. Goetz, E. Jeanes, and A. McBride. 2011. Marine Habitat Use by Anadromous Bull Trout from the Skagit River, Washington, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 3:1, 394-410.

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. NOAA Technical Memorandum NMFS-NWFSC-83.

Herkert, J. 1994. The Effects of Habitat Fragmentation on Midwestern Grassland Bird Communities. *Ecological Applications*, *4*(3), 461–471. Retrieved from http://www.jstor.org/stable/1941950.

Herkert, J. R., D.A. Reinking, D.A. Wiedenfeld., M. Winter, J.L Zimmerman, W.E. Jensen, S.K. Robinson. 2007. Effects of Prairie Fragmentation on the Nest Success of Breeding Birds in the Midcontinental United States. Conservation Biology, 17(2), 587–594.

Herrera Environmental Consultants. 2007. Crockett Lake Functional Assessment and Historical Analysis of Crockett Lake at Ebey's Landing National Historic Reserve. Prepared for National Park Service. November 15, 2007.

Heisler, J., M. Glibertb, J.M. Burkholder, D.M. Anderson, W. Cochlane, W.C. Dennison, Q. Dortch, C.J. Gobler, C.A. Heil, E. Humphries, A. Lewitus, R. Magnien, H.G. Marshall, K. Sellner, D.A. Stockwell, D.K. Stoecker, M. Suddleson. 2008. Eutrophication and harmful algal blooms: A scientific consensus. Harmful Algae 8 (3-13)

Heithecker, T. and C. Halpern. 2006. Variation in microclimate associated with dispersed-retention harvests in coniferous forests of western Washington. Forest Ecology and Management 226(1-3): 60-71.

Heithecker, T. and C. Halpern. 2007. Edge-related gradients in microclimate in forest aggregates following structural retention harvests in western Washington. for Ecol Manage 248(3):163-73.

Helmers, M.J., D.E. Eisenhauer, M.G. Dosskey, T.G. Franti, J.M. Brothers, and M.C. McCullough. 2005. Flow pathways and sediment trapping in a field-scale vegetative filter. Transactions of the ASAE 48:955-968.

Henderson, R., A. Kagley, K. Fresh, E. Beamer, A. McBride, K. Wolf. 2007. Juvenile salmon and nearshore fish use in shallow intertidal habitat associated with Race Lagoon, 2006 and 2007.

Hennings, L.A. and W.D. Edge. 2003. Riparian bird community structure in Portland, Oregon: Habitat, urbanization, and spatial scale patterns. Condor 105:288–302.

Herlihy, A.T., W.J. Gerth, J. Li, and J.L. Banks. 2005. Macroinvertebrate community response to natural and forest harvest gradients in western Oregon headwater streams. Freshwater Biology.

Hill, A. R. 1996. Nitrate removal in stream riparian zones. Journal of Environmental Quality 25(4):743:755.

Hilty, J.A., W.Z. Lidicker Jr., and A.M. Merenlender. 2006. Corridor Ecology: The science and practice of linking landscapes for biodiversity conservation. Island Press, Washington, DC.

Hinman, C. 2009. Flow Control and Water Quality Treatment Performance of a Residential Low Impact Development Pilot Project in Western Washington. Report to Water Environment Research Foundation.

Hood, WG. 2007 Large woody debris influences vegetation zonation in an oligohaline tidal marsh. Estuaries & Coasts. 30:441-450

Hoover S., L. Shannon, J. Ackerman. 2007. The effect of riparian condition on invertebrate drift in mountain streams. Aquatic Science 69(4):544-53.

Hosack, G.R., B.R. Dumbauld, J.L. Ruesink, and D.A. Armstrong. 2006. Habitat associations of estuarine species: comparisons of intertidal mudflat, seagrass (*Zostera marina*), and oyster (*Crassostrea gigas*) habitats. Estuaries and Coasts 29: 1150-1160.

Howe, E. 2012. Detrital Shadows: Evaluating Landscape and Species Effects on Detritus Based Food Web Connectivity in Pacific Northwest Estuaries. PhD Dissertation. University of Washington.

Hruby, T. Washington State Wetland Rating System for Western Washington, Revised. Washington Department of Ecology. Publication # 04-06-025.

Island County. 1998. Island County Comprehensive Plan, Natural Lands Element. Adopted September 28, 1998. Available on line at: http://www.islandcounty.net/planning/pdf/compplan/Natural%20Lands%20Element.pdf

Island County Public Works. 2004. Management Plan for the Grasser's Hill Population of Western Blue Flag (*Iris missouriensis*. Nutt.) Island County Public Works, January 28, 2004.

Island County. 2005. Island County Water Resource Management Plan. Water Resources Advisory Committee.

Island County Comprehensive Plan, Parks and Recreation, Element 7. December 12, 2011.

Island County Environmental Health. 2013. Island County Surface Water Monitoring Program. Water Years 2007 to 2011. Internal draft report provided courtesy of Karen Dubose, Island County Environmental Health.

Island County. 2013. Island County 2016 Periodic Comprehensive Plan Update Population Projections and Trends. Presentation by Island County Planning and Community Development. June 19, 2013.

Island County. Electronic reference. Island County Department of Health. http://www.islandcountyeh.org/Page/98 [Accessed November 21, 2013].

Jackson, C. R., D.P. Batzer, S.S. Cross, S.M. Haggerty, C.A Sturm. 2007. Headwater streams and timber harvest: Channel, macroinvertebrate, and amphibian response and recovery. Forest Science.

Janisch, J.E., S.M. Wondzell, and W.J. Ehinger. 2012. Headwater Stream Temperature: Interpreting Response after Logging, with and Without Riparian Buffers, Washington, USA. Forest Ecology and Management 270: 302–313.

Jensen, D.W., E.A. Steel, A.H. Fullerton, G.R. Pess. 2009. Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies. Reviews in Fisheries Science.

Jin, C.X. and M.J.M. Romkens. 2001. Experimental studies of factors in determining sediment trapping in vegetative filter strips. Trans. ASAE 44:277-288.

Johannessen, J. and M. Chase. 2005. Island County Feeder Bluff Accretion Shoreform Mapping. November 2005.

Johannessen, J. and A. MacLennan. 2007. Beaches and Bluffs of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-04. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington. Available at www.pugetsoundnearshore.org.

Johnson, D.H. and T.A. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press. Corvallis, Oregon. 736 pp.

Johnson, S.L. 2004. Factors influencing stream temperatures in small streams : substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences 61: 913–923.

Johnston, N. T., S.A. Bird, D.L. Hogan, and E.A. MacIsaac. 2011. Mechanisms and source distances for the input of large woody debris to forested streams in British Columbia, Canada. Canadian Journal of Forest Research, 41(11), 2231–2246.

Jones, J.A. 2000. Hydrologic processes and peak discharge response to forest removal, regrowth, and roads in 10 small experimental basins, western Cascades, Oregon. Water Resources Research.

Jordan, N. R., D.L. Larson, and S.C. Huerd. 2007. Soil modification by invasive plants: effects on native and invasive species of mixed-grass prairies. Biological Invasions, 10(2), 177–190.

Kagley, A., T. Zackey, K. Fresh, E. Beamer. 2007. Juvenile salmon and nearshore fish use in shoreline and lagoon habitat associated with Elger Bay, 2005-2007.

Karr, J.R. 1998. Rivers as Sentinels: Using the Biology of Rivers to Guide Landscape Management. In River Ecology and Management: Lessons from the Pacific Coastal Ecoregion, ed. R.J. Naiman and R.E. Bilby, 502-528. New York: Springer-Verlag.

Kaufmann, P.R and J.M. Faustini. 2012. Simple measures of channel habitat complexity predict transient hydraulic storage in streams. Hydrobiologia.

Kaushal, S. S., M. L. Pace, P. M. Groffman, L. E. Band, K. T. Belt, P. M. Meyer, and C. Welty (2010), Land Use and Climate Variability Amplify Contaminant Pulses, Eos Trans. AGU, 91(25), 221–222,

Keller, C.M.E., C.S. Robbins, and J.S. Hatfield. 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. Wetlands 13:137-144.

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surf. Process. Landforms 4: 361-380.

Keller, I. and C.R. Largiadèr. 2003. Recent habitat fragmentation caused by major roads leads to reduction of gene flow and loss of genetic variability in ground beetles. Proceedings. Biological Sciences / The Royal Society 270 (1513):417–23.

Keller, I., W. Nentwig, and C.R. Largiader. 2004. Recent habitat fragmentation due to roads can lead to significant genetic differentiation in an abundant flightless ground beetle. Molecular Ecology 13 (10): 2983–94.

Kelly J.M., J.L. Kovar, R. Sokolowsky, T.B. Moorman. 2007. Phosphorus uptake during four years by different vegetative cover types in a riparian buffer. Nutrient Cycling Agroecosystems 78(3):239-51.

Kiffney, P.M. and J.S. Richardson. 2010. Organic matter inputs into headwater streams of southwestern British Columbia as a function of riparian reserves and time since harvesting. Forest Ecology and Management.

Kiffney P., J. Richardson, and J. Bull. 2003. Responses of periphyton and insects to experimental manipulation of riparian buffer width along forest streams. Journal of Applied Ecology 40(6):1060-76.

Kiffney, P M., J.S. Richardson, and J.P. Bull 2004. Establishing light as a causal mechanism structuring stream communities in response to experimental manipulation of riparian buffer width. Journal of the North American Benthological Society 23(3):542-555.

Kind, P., G. Rosling, K. Kreamer, H. Flores, F. Wood. 2010. Prey selection by pigeon guillemots nesting on Whidbey Island, Washington. http://pigeonguillemot.org/)

Kissling, M.L and E.O. Garton. 2008. Forested buffer strips and breeding bird communities in Southeast Alaska. Journal of Wildlife Management 72(3):674-681.

Klubar, M.R., D.H. Olson, and K.J. Puettmann. 2008. Amphibian distributions in upslope areas and their habitat associations on managed forest landscapes in the Oregon coast range. For. Ecol. ad Manage. 256:529-535

Knopf, F.L., R.R. Johnson, T. Rich, F.B. Samson, and R.C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bull. 100:272-284.

Knutson, K.L. and V.L. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Washington Department of Fish and Wildlife, Olympia, Washington. 181pp.

Konrad, C.P., and D.B. Booth. 2005. Hydrologic changes in urban streams and their ecological significance. In L. R. Brown, R. H. Gray, R. M. Hughes, and M. R. Meador (editors). Effects of urbanization on stream ecosystems. Symposium 47. American Fisheries Society, Bethesda, Maryland (in press).

Konrad, C.P., D.B. Booth, and S.J. Burges. 2005. Effects of urban development in the Puget Lowland, Washington, on interannual streamflow patterns: Consequences for channel form and streambed disturbance. Water Resources Research 41(7): W0700.

Kunze, L.M. 1994. Preliminary Classification of Native, Low Elevation Freshwater Wetland Vegetation in Western Washington.

Lawrence, B.A. and Kaye, T.N. 2006. Habitat Variation Throughout the Historic Range of Golden Paintbrush, a Pacific Northwest Prairie Endemic: Implications for Reintroduction. Northwest Science, Vol. 80, No. 2: 140-152.

Lazzaro, L., Otto, S., and G. Zanin. 2008. Role of hedgerows in intercepting spray drift: Evaluation and modelling of the effects. Agriculture, Ecosystems and Environment 123(4):317-327; Feb 2008

Lee, K. H., T.M. Isenhart, and R.C. Schultz. 2003. Sediment and nutrient removal in an established multi-species riparian buffer. Journal of Soil and Water Conservation 58(1):1-10.

Lehtinen, R.M., S.M. Galatowitsch, and J.R. Tester. 1999. Consequences and habitat loss and fragmentation for wetlands amphibian assemblages. Wetlands 19:1-12.

Lens, L. and A.A. Dhondt. 1994. Effects of habitat fragmentation on the timing of Crested Tit Parus cristatus natal dispersal. Ibis 135:147-152.

Lewis, J.C. and J.M. Azerrad. 2003. Pileated Woodpecker. Pages 29-1 to 29-9 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Lewis, J.C., R. Milner, and M. Whalen. 1999. Common Loon. Pages 1-1 to 1-4 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Lienkaemper, G.W., and F.J. Swanson. 1987. Dynamics of large woody debris in streams in old-growth Douglas-fir forests. Canadian Journal of Forest Research 17:150-156.

Long, E. R., M. Dutch, S. Weakland, B. Chandramouli and J.P. Benskin. 2013. Quantification of pharmaceuticals, personal care products, and perfluoroalkyl substances in the marine sediments of Puget Sound, Washington, USA. Environmental Toxicology and Chemistry 32: 1701–1710.

Mabry, K.E. and G.W. Barrett. 2002. Effects of corridors on home range sizes and interpatch movements of three small mammal species. Landscape Ecol. 17:629-636

Machtans, C.S., M.A. Villard, and S.J. Hannon. 1996. Use of riparian buffer strips as movement corridors by forest birds. Conserv. Biol. 10:1366-1379.

MacLennan, A. 2005. An analysis of large woody debris in two Puget Sound salt marshes; Elger Bay, Camano Island, and Sullivan Minor Marsh, Padilla Bay. Bellingham, WA, Western Washington University. MS Thesis: 128.

Mallin, M., K. Williams, E. Esham, and R. Lowe. 2000. Effect of human development on bacteriological water quality in coastal watersheds. Ecological Applications 10:1047–1056.

Marzluff, J.M. 2001. Worldwide urbanization and its effects on birds. Pages 19-48 in Marzluff, J.M., R. Bowman, and R. Donnelly, editors. Avian Conservation and Ecology in an Urbanizing World. Kluwar Academic Press, Norwell, MA. 585pp.

Marzluff, J.M and K. Ewing. 2001. Restoration of fragmented landscapes for the conservation of birds: a general framework and specific recommendations for urbanizing landscapes. Restoration Ecology 9:280-292.

Marzluff, J.M. 2005. Island biogeography for an urbanizing world: how extinction and colonization may determine biological diversity in human-dominated landscapes. Urban Ecosystems 8:157-177.

Mason J., C. Moorman, G. Hess, and K. Sinclair. 2007. Designing suburban greenways to provide habitat for forest-breeding birds. Landscape Urban Planning 80(1-2):153-64.

May, C. L., and R.E. Gresswell. 2003. Large wood recruitment and redistribution in headwater streams in the southern Oregon Coast. Canadian Journal of Forest Research, 33, 1352–1362. doi:10.1139/X03-023.

May, C. W., R. R. Horner, J. R. Karr, B. W. Mar, and E. B. Welch. 1997. Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques Vol. 2, No. 4.

Mayer, P.M., S.K. Reynolds, J. Marshall, D. McCutchen, and T.J. Canfield. 2007. Meta-Analysis of Nitrogen Removal in Riparian Buffers. Journal of Environmental Quality. 36: 1172-1180.

Mayer, P.M., S.K. Reynolds, D. McCutchen, and T.J. Canfield. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. EPA/600/R-05/118. Cincinnati, Ohio, U.S. Environmental Protection Agency.

McBride, A. and E. Beamer. 2010. Feasibility assessment for salt marsh restoration at Camano Island State Park, Whidbey Basin. Skagit River System Cooperative, LaConner, WA.

McBride, M. and D.B. Booth. 2005. Urban impacts on physical stream condition: Effects of spatial scale, connectivity, and longitudinal trends. Journal of the American Water Resources Association 41:565-580.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Can J Forest Res 20:326–330

McIlroy, S.K., C. Montagne, C.A. Jones, B.L. McGlynn. 2008. Identifying linkages between land use, geomorphology, and aquatic habitat in a mixed-use watershed. Environ Manage 42(5):867-76.

McIntyre, J.W. and J.F. Barr. 1997. Common loon, Gavia immer. In A. Poole and F. Gill, (eds.) The Birds of North America, 313. Acad. Nat. Sci. Phil. and Amer. Ornith. Union, Washington D.C.

McKinney, M. L. (2002). Urbanization, Biodiversity, and Conservation. BioScience, 52(10).

Melles, S., S. Glenn, and K. Martin. 2003. Urban bird diversity and landscape complexity: species-environment associations along a multiscale habitat gradient. Conserv. Ecol. 7 [online].

Mickelson, E. 2009. Crescent Creek freshwater input analysis. Prepared for Island County and Washington Department of Fish and Wildlife.

Miller, B., C. Simenstad, J. Cross, K. Fresh, and S. Steinfort. 1980. Nearshore fish and macroinvertebrate assemblages along the Strait of Juan de Fuca including food habits of the common nearshore fish- Final report of three years' sampling, 1976-1979. Prepared for Marine Ecosystems Analysis Puget Sound Project, Seattle, Washington.

Mills, L.J. 2005. Review of evidence: Are endocrine-disrupting chemicals in the aquatic environment impacting fish populations? Science and the Total Environment 343(1-3):1-34.

Miltner, R., D. White, and C. Yoder. 2004. The biotic integrity of streams in urban and suburbanizing landscapes. Landscape Urban Planning 69(1):87-100.

Misra, A.K., J.L. Baker, S.K. Mickelson, and H. Shang. 1996. Contributing area and concentration effects on herbicide removal by vegetative buffer strips. Transactions ASAE 39:2105-2111.

Monohan, C.E. 2004. Riparian buffer function with respect to nitrogen transformation and temperature along lowland agricultural streams in Skagit County, Washington. Dissertation, Univ. Washington, Seattle.

Montgomery, D.R., and W.E. Dietrich. 1992. Channel initiation and the problem of landscape scale. Science (New York, N.Y.) 255: 826–30.

Montgomery, D.R., T.B. Abbe, J.M. Buffington, N. Peterson, K.M. Schmidt, and J.D. Stock. 1996. Distribution of bedrock and alluvial channels in forested mountain drainage basins. Nature 381: 587-589.

Moore, A.A. and M.A. Palmer. 2005. Invertebrate biodiversity in agricultural and urban headwater streams: Implications for conservation and management. Ecological Applications 15:1169-1177.

Moore, R.D. and S.M. Wondzell. 2005. Physical hydrology and the effects of forest harvesting in the Pacific Northwest: a review. Journal of the American Water Resources Association 41:763-784.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41:813-834.

Morley, S. A., J. R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. Conservation Biology, 16:1498-1509.

Mumford, T. F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Murphy, M. L. and K. V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North American Journal of Fisheries Management. 9(4):427-436.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Connor, P.L. Olson, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion, p. 127-188. In: R.J. Naiman (ed.), Watershed Management: Balancing Sustainability and Environmental Change. Springer-Verlag, New York.

Naiman, R.J., C.A. Johnson, and J.C. Kelley. Alteration of North American Streams by Beaver: structure and dynamics of streams are changing as beaver recolonize their historic habitat. Bioscience 38(11)753-762.

Nakamura, F. and F. Swanson. 1993. Effects of coarse woody debris on morphology and sediment storage of a mountain stream system in western Oregon. Earth Surface Processes and Landforms 18: 43-61.

Nakamura, F., F.J. Swanson, and S.M. Wondzell. 2000. Disturbance regimes of stream and riparian systems -- a disturbance-cascade perspective. Hydrological Processes 14:2849-2860.

National Marine Fisheries Service (NMFS). 2005. Stock Assessment Report Humpback Whale (*Megaptera novaeangliae*): Eastern North Pacific Stock.

_______. 2008. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*).

_______. 2010. Status Review of Five Rockfish Species in Puget Sound, Washington, Bocaccio (*Sebastes paucispinis*), Canary Rockfish (*S. pinniger*), Yelloweye Rockfish (*S. ruberrimus*), Greenstriped Rockfish (*S. elongatus*),and Redstripe Rockfish (*S. proriger*). NOAA Technical Memorandum NMFS-NWFSC-108.

_______. 2013. Status Review of The Eastern Distinct Population Segment of Steller Sea Lion (*Eumetopias jubatus*). 144pp + Appendices. Protected Resources Division, Alaska Region.

Natural Resource Conservation Service (NRCS). Electronic reference. Field Office Technical Guide for Island County, WA. http://efotg.sc.egov.usda.gov/toc.aspx?CatID=16160 [Accessed December 26, 2013].

Nelitz M.A., E.A. MacIsaac, and R.M. Peterman. 2007. A science-based approach for identifying temperature-sensitive streams for rainbow trout. N Am J Fish Manage 27(2):405-24.

Nelson, G.S. and S.M. Nelson. 2001. Bird and butterfly communities associated with two types of urban riparian areas. Urban Ecosystems 5:95-108.

Ness, A.O. and C.G. Richins. 1958. Soil Survey of Island County, Washington. United States Department of Agriculture, Soil Conservation Service in cooperation with Washington Agricultural Experiment Station, Institute of Agricultural Science, State College of Washington.

Newbold, J. D., S. Herbert, B.W. Sweeney, P. Kiry, and S.J. Alberts. 2010. Water Quality Functions of a 15-Year-Old Riparian Forest Buffer System. JAWRA Journal of the American Water Resources Association, 46: 299–310.

Office of Financial Management and Budget. 2012. County Growth Management Population Projections by Age and Sex: 2010 – 2040, OFM, August 2012

Olden, J. D., L. Poff, M.R. Douglas, M.E. Douglas and K.D. Fausch. 2004. Ecological and evolutionary consequences of biotic homogenization. Trends in ecology & evolution, 19(1), 18–24.

O'Neill, S.M., J.E. West, and J.C. Hoeman. 1998. Spatial Trends in the Concentration of Polychlorinated Biphenyls (PCBs) in Chinook (Oncorhynchus tshawytscha) and Coho Salmon (O. kisutch) in Puget Sound and Factors Affecting PCB Accumulation: Results from the Puget Sound Ambient Monitoring Program. Washington Department of Fish and Wildlife.

Olson D, P. Anderson, C. Frissell, H. Welsh, and D. Bradford. 2007. Biodiversity management approaches for stream-riparian areas: Perspectives for Pacific northwest headwater forests, microclimates, and amphibians. for Ecol Manage 246(1):81-107.

Oneal, A. and J. Rotenberry. 2009. Scale-dependent habitat relations of birds in riparian corridors in an urbanizing landscape. Landscape Urban Planning 92(3-4):264-75.

Orca Network. Electronic reference. http://www.orcanetwork.org [Accessed 11/7/2013]

Orrock, J. L. and B. J. Danielson. 2005. Patch shape, connectivity, and foraging by the oldfield mouse, Peromyscus polionotus. Journal of Mammalogy 86: 569-575.

Osborne, L. L., and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater biology 29:243-258.

Otto S., M. Vianello, A. Infantino, G. Zanin, and A. Di Guardo. 2008. Effect of a full-grown vegetative filter strip on herbicide runoff: Maintaining of filter capacity over time. Chemosphere 71(1):74-82.

Pacific Rim Institute Management Plan. 2013. Peter W. Dunwiddie, Robert K. Pelant, Randall Van Dragt, Joe K. Sheldon, Seth Luginbill. Habitat Restoration and Management Plan for Smith Prairie at the Pacific Rim Institute. March 22, 2013.

Pardini, R, S. Marques de Souza, R. Braga-Neto, and JP Metzger. 2005. The role of forest structure, fragment size, and corridors in maintaining small mammal abundance and diversity in an Atlantic forest landscape. Biological Conservation 124: 253-266.

Parker, T.H., B.M. Stansberry, C.D. Becker, and P.S. Gipson. 2005. Edge and area effects on the occurrence of migrant forest songbirds. Conservation Biology 19:1157-1167.

Parks, D., A. Shaffer, and D. Barry. 2013. Nearshore Drift-Cell Sediment Processes and Ecological Function for Forage Fish: Implications for Ecological Restoration of Impaired Pacific Northwest Marine Ecosystems. Journal of Coastal Research 29(4)984 – 997.

Parkyn, S. 2004. Review of Riparian Buffer Zone Effectiveness. Canada Ministry of Agriculture and Forestry (MAF). Technical Paper No: 2004/05.

Pasitschniak-Arts, M., and F. Messier. 1995. Risk of predation on waterfowl nests in the Canadian prairies: effects of habitat edges and agricultural practices. Oikos 73: 347- 355.

Peak, R.G. and F.R. Thompson. 2006. Factors affecting avian species richness and density in riparian areas. Journal of Wildlife Management 70(1):173–179.

Pearson, S.F. and D.A. Manuwal. 2001. Breeding bird response to riparian buffer width in managed Pacific Northwest Douglas fir forests. Ecological Applications 11: 840-853.

Pearsons T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. Transactions of the American Fisheries Society 121: 427-436.

Penttila, D.E. 2001. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt, Hypomesus, on upper intertidal beaches in Northern Puget Sound. In: Proceedings of Puget Sound Research, 2001 Conference. Puget Sound Action Team, Olympia, WA.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Pess, G.R., D.R. Montgomery, E.A. Steel, R.E. Bilby, B.E. Feist, H.M. Greenberg. 2002. Landscape characteristics, land use, and coho salmon (Oncorhynchus kisutch) abundance, Snohomish River, Wash., U.S.A. Canadian Journal of Fisheries & Aquatic Sciences.

Peterson, B.J., W.M. Wollheim, P.J. Mulholland, J.R. Webster, J.L. Meyer, J.L. Tank, E. Martí, W.B. Bowden, H.M. Valett, A.E. Hershey, W.H. McDowell, W.K. Dodds, S.K. Hamilton, S. Gregory, and D. Morrall. 2001. Control of nitrogen export from watersheds by headwater streams. Science. 292: 86-90.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics, 52(3), 273–288.

Pollock, M.M., T.J. Beechie, M. Liermann, and R.E. Bigley. 2009. Stream temperature relationships to forest harvest in western Washington. Journal of the American Water Resources Association 45(1):141–156.

Pollock, M., G. Pess, T. Beechie, D. Montgomery. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River basin, Washington, USA. American Journal of Fisheries Management 24: 749-760.

Polyakov, V. A. Fares, and M.H. Ryder. 2005. Precision Riparian Buffers for the Control of Nonpoint Source Pollutant Loading into Surface Water: A Review. Environmental Review. 13: 129-144. Published on the NRC Research Press Web site at http://er.nrc.ca/ on 16 August 2005.

Poole, G.C. and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6): 787-802.

Poor, C. and J. McDonnell. 2007. The effects of land use on stream nitrate dynamics. Journal of Hydrology 332(1-2):54-68.

Progar, R. and A. Moldenke. 2009. Aquatic insect emergence from headwater streams flowing through regeneration and mature forests in western Oregon. Journal of Freshwater Ecology 24(1):53-66.

Qiu, Z. 2003. A VSA-based strategy for placing conservation buffers in agricultural watersheds. Environmental Management 32:299-311.

Qiu, Z. 2009. Assessing Critical Source Areas in Watersheds for Conservation Buffer Planning and Riparian Restoration. Environmental Management: 44:968-980.

Rayne, S., G. Henderson, P. Gill, and K. Forest. 2008. Riparian forest harvesting effects on maximum water temperatures in wetland-sourced headwater streams from the Nicola river watershed, British Columbia, Canada. Water Resour Manage 22(5):565-78.

Reichard, S.H., L. Chlker-Scott, and S. Buchanan. 2001. Interactions among non-native plants and birds. Pages 179-223 in Marzluff, J.M., R. Bowman, and R. Donnelly, editors. Avian Conservation and Ecology in an Urbanizing World. Kluwar Academic Press, Norwell, MA. 585pp.

Reichenberger, S., M. Bach, A. Skitschak, and H.G. Frede. 2007. Mitigation strategies to reduce pesticide inputs into ground- and surface water and their effectiveness; a review. Science and the Total Environment 384(1-3):1-35.

Reid, L. and S. Hilton. 1998. Buffering the Buffer. Proceedings of the conference on coastal watersheds: the Caspar Creek Story; 6 May 1998, Ukiah, CA, United States Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Relyea, R.A. 2005. The lethal impact of Roundup® on aquatic and terrestrial amphibians. Ecological Applications 15:1118-1124

Ricciardi, A., R.L. Neves, and J.B. Rasmussen. 1998. Impending extinctions of North American freshwater mussels (Unionoida) following the zebra mussel (Dreissena polymorpha) invasion. Journal of Animal Ecology 67(4), 613–619.

Rice, C.A. 2006. Effects of shoreline modification on a northern Puget Sound beach: microclimate and embryo mortality in surf smelt (Hypomesus pretiosus). Estuaries and Coasts 29(1): 63-71

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY. Partners in Flight website. http://www.partnersinflight.org/cont_plan/ (VERSION: March 2005).

Richardson, C. T., and C.K. Miller. 1997. Recommendations for protecting raptors from human disturbance : a review. Wildlife Society Bulletin, 25(3), 634–638.

Richardson, S. A., D. Hays, R. Spencer, and J. Stofel. 2000. Washington State status report for the common loon. Washington Dept. of Fish and Wildlife, Olympia, WA.

Robison, E.G. and R.L. Beschta. 1990. Identifying trees in riparian areas that can provide coarse woody debris to streams. Forest Science. 36(3):790-801

Rodewald, A.D. 2003. The importance of land uses within the landscape matrix. Wildlife Society Bulletin 31:586-592.

Rodgers, Jr, J. A. and S.T. Schwikert. 2002. Buffer-Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-Powered Boats. Conservation Biology, 16(1), 216–224.

Roni, P., T. Beechie, R. Bilby, F. Leonetti, M. Pollock, and G. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1-20.

Roni, P. and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries & Aquatic Sciences.

Ross, P.S., G.M. Ellis, M.G. Ikonomou, L.G. Barrett-Lennard and R.F. Addison. 2000. High PCB Concentrations in Free-Ranging Pacific Killer Whales, Orcinus orca: Effects of Age, Sex and Dietary Preference. Marine Pollution Bulletin. Vol. 40, No. 6: 504-515.

Rottenborn, S.C. 1999. Predicting the impacts of urbanization on riparian bird communities. Biol. Conserv. 88:289-299.

Roy, A. H., A. D. Rosemond, M. J. Paul, D. S. Leigh, and J. B. Wallace. 2003. Stream macroinvertebrate response to catchment urbanization (Georgia, U.S.A.). Freshwater Biology 22:329–346.

Rubbo, M. J., and J.M. Kiesecker. 2005. Amphibian Breeding Distribution in an Urbanized Landscape. Conservation Biology, 19(2), 504–511.

Schaefer, V. 2003. Green links and urban biodiversity: an experiment in connectivity. 2003 Proceedings of the Georgia Basin/Puget Sound Research Conference. 9pp.

Schiel, D.R., S.A. Wood, R.A. Dunmore, and D.I. Taylor. 2006. Sediment on rocky intertidal reefs: Effects on early post-settlement stages of habitat-forming seaweeds. Journal of Experimental Marine Biology and Ecology 331: 158-172.

Schlenger, P., A. MacLennan, E. Iverson, K. Fresh, C. Tanner, B. Lyons, S. Todd, R. Carman, D. Myers, S. Campbell, and A. Wick. 2011. Strategic Needs Assessment: Analysis of Nearshore Ecosystem Process Degradation in Puget Sound. Prepared for the Puget Sound Nearshore Ecosystem Restoration Project. Technical Report 2011-02.

Scholz, N.L., M.S. Myers, S.G. McCarthy, J.K. McIntyre, et al. 2011. Recurrent die-offs of adult coho salmon returning to spawn in the Puget Sound lowland urban streams. PLoS One 6(12).

Seattle Audubon Society. 2005. Bird Web online guide to the birds of Washington. www.birdweb.org. Seattle, WA.

Sedell, J.R., P.A. Bisson, F.J. Swanson, and S.V. Gregory. 1988. What we know about large trees that fall into streams and rivers. In Maser C., R.F. Tarrant, J.M. Trappe, and J.F. Franklin. From the Forest to the Sea: a Story of Fallen Trees. USDA Forest Service General Technical Report PNW-GTR-229.

Segura, C. and D. B. Booth. 2010. Effects of Geomorphic Setting and Urbanization on Wood, Pools, Sediment Storage, and Bank Erosion in Puget Sound Streams. JAWRA Journal of the American Water Resources Association 46: 972–986.

Semlitsch, R.D. and J.R. Bodie. 2003. Biological Criteria for buffer zones around wetland and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219-1228.

Shandas, V. and M. Alberti. 2009. Exploring the role of vegetation fragmentation on aquatic conditions: Linking upland with riparian areas in Puget Sound lowland streams. Landscape Urban Planning 90(1-2):66-75.

Shattuck, B. and D. Marks. 2009. Recent Trends of Timber Harvest and Conversion Rates in WRIAs 5, 6 and 7; An Analysis of FPAs for 2005 – 2008. Poster at 2009 Northwest Indian Fisheries Commission Tribal Habitat Conference.

Sheehan, M. 2007. Prairie and Oak Woodland Habitats and Associated Rare Species on Whidbey Island. Whidbey Camano Land Trust.

Sheridan, C. and D. Olson. 2003. Amphibian assemblages in zero-order basins in the Oregon coast range. Canadian Journal for Research 33(8):1452-77.

Sheridan, J.M., R. Lowrance, and D.D. Bosch. 1999. Management effects on runoff and sediment transport in riparian forest buffers. Transactions of the American Society of Agricultural Engineers 42(1): 55-64.

Shipman, H. 2001. Coastal Landsliding on Puget Sound: A Review of Landslides Occurring Between 1996 and 1999. Department of Ecology Report #01-06-019

Shipman, H. 2004. Coastal Bluffs and Sea Cliffs on Puget Sound, Washington. USGS Professional Paper 1693

Shirley, S.M. 2006. Movement of forest birds across river and clearcut edges of varying riparian buffer strip widths. Forest Ecology and Management 223(1):190-199.

Shirley, S.M. and J.N.M. Smith. 2005. Bird community structure across riparian buffer strips of varying width in a coastal temperate forest. Biological Conservation 125:475-489.

Simenstad, C.A., M. Ramirez, J. Burke, M. Logsdon, H. Shipman, C. Tanner, J. Toft, B. Craig, C. Davis, J. Fung, P. Bloch, K. Fresh, S. Campbell, D. Myers, E. Iverson, A. Bailey, P. Schlenger, C. Kiblinger, P. Myre, W. Gerstel, and A. MacLennan. 2011. Historical Change of Puget Sound Shorelines: Puget Sound Nearshore Ecosystem Project Change Analysis. Puget Sound Nearshore Report No. 2011-01. Published by Washington Department of Fish and Wildlife, Olympia, Washington, and U.S. Army Corps of Engineers, Seattle, Washington.

Slater, G.L. and C. Rock. (2005, September 30). Northern Harrier (*Circus cyaneus*): A technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/northernharrier.pdf [1/23/2014].

Smith, D.R., E.A. Warnemuende, B.E. Haggard, and C. Huang. 2006. Dredging of drainage ditches increases short-term transport of soluble phosphorus. Journal of Environmental Quality 35: 611-616.

Smith, D.R., C.M. Smith, E.A. Warnemuende, and C. Huang. No date. Dredging of drainage ditches can increase short-term contaminant transport. US Department of Agriculture and National Soil Erosion Research Laboratory.

Sobocinski, K.L., J.R. Cordell, and C.A. Simenstad. 2010. Effects of shoreline modifications on supratidal macroinvertebrate fauna on Puget Sound, Washington beaches. Estuaries and Coasts 33(3): 699-711.

Sobota, D. J., S.L., Johnson, S.V. Gregory, and L.R. Ashkenas. 2012. A Stable Isotope Tracer Study of the Influences of Adjacent Land Use and Riparian Condition on Fates of Nitrate in Streams. Ecosystems 15:1-17

Soranno, P.A., S.L. Hubler, S.R. Carpenter, and R.C. Lathrop. 1996. Phosphorus loads to surface waters: A simple model to account for spatial pattern of land use. Ecological Applications 6(3): 865-878.

Southerland, M. 1993. Habitat Evaluation: Guidance for the review of environmental impact assessment documents. Prepared for the U.S. Environmental Protection Agency.

Spromberg, J.A. and N.L. Scholz. 2011. Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management 7(4): 648-656.

Sridhar, V., A.L. Sansone, J. LaMarche, T. Dubin, and D.P. Lettenmaier. 2004. Prediction of Stream Temperature in Forested Watersheds. Journal of the American Water Resources Association (JAWRA) 40(1): 197-213.

SRP (Salmon Recovery Plan Technical Advisory Group: WRIA 6). 2005. WRIA 6 (Whidbey and Camano Islands) Multi-Species Salmon Recovery Plan. Adopted by the Island County Water Resources Advisory Committee and Board of Island County Commissioners.

Stalmaster, M. V., & Kaiser, J. L. 1997. Flushing responses of wintering bald eagles to military activity. The Journal of Wildlife Management 61(4), 1307–1313.

Stanley, S., S. Grigsby, D. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, and G. Wilhere. 2012. Puget Sound Characterization, Volume 1: The Water Resource Assessments (Water Flow and Water Quality). Ecology Publication # 11-06-016.

Steidl, R. J. and R.G. Anthony. 2000. Experimental effects of human activity on breeding bald eagles. Ecological Applications 10(1): 258–268.

Steneck, R., M. Graham, B. Bourque, D. Corbett, J. Erlandson, J. Estes, M. Tegner. 2002. Kelp forest ecosystems: biodiversity, stability, resilience and future. Environmental Conservation 29(4):436-459.

Stephenson, J. M., and A. Morin. 2009. Covariation of stream community structure and biomass of algae, invertebrates and fish with forest cover at multiple spatial scales. Freshwater Biology 54(10): 2139-2154.

Stinson, D. 2005. Washington State Status Report for the Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot. WDFW, Wildlife Program. Olympia, WA.

Stinson, D. W., J.W. Watson, and K.R. Mcallister. 2007. Status Report for the Bald Eagle. Washington State Department of Fish and Wildlife.

Stoddard, M.A. and J.P. Hayes. 2005. The influence of forest management on headwater stream amphibians at multiple spatial scales. Ecological Applications 15(3): 811-823; June 2005. ISSN: 1051-0761

Story, A., R. Moore, and J. Macdonald. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research 33(8): 1383-1396.R.

Suttle, K. B., M. Power, J. Levine, and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological Applications 14(4):969-974.

Swanson, F. J., T. K. Kratz, N. Caine, and R. G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. BioScience 38: 92-98.

Swanson F.J. and G.W. Lienkaemper. 1978. Physical consequences of large organic debris in Pacific Northwest streams. GTR-PNW-69. Pacific Northwest Range and Experiment Station, Portland, OR.

Swanson F.J., G.W. Lienkaemper, and J.R. Sedell. 1976. History, physical effects, and management implications of large organic debris in western Oregon streams. USDA Forest Service General Technical Report PNW-56.

Thompson, D.G., B.F. Wojtaszek, B. Staznik, D.T., and G.R. Stephenson. 2004. Chemical and biomonitoring to assess potential acute effects of Vision® herbicide on native amphibian larvae in forest wetlands. Environmental Toxicology and Chemistry 23: 843-849.

Todd, B.D., T. Luhring, B. Rothermel, J. Whitfield Gibbons. 2009. Effects of forest removal on amphibian migrations: implications for habitat and landscape connectivity. Journal of Applied Ecology 46:3, 554-561

Tomer, M., M. Dosskey, M. Burkart, D. James, M. Helmers, and D. Eisenhauer. 2009. Methods to Prioritize Placement of Riparian Buffers for Improved Water Quality. Agroforestry Systems 75:17-25.

Tremblay, MA and CC St Clair. 2009. Factors affecting the permeability of transportation and riparian corridors to the movements of songbirds in an urban landscape. J. Applied Ecol. 46:1314-1322.

Tschapalinski, P. J. and Hartman, G. F. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Sciences 40(4):452-461.

United States Department of Agriculture (USDA). 2007. 2007 Census of Agriculture County Profile Island County, Washington.

United States Environmental Protection Agency (USEPA). 2003. EPA Region 10 guidance for Pacific Northwest state and tribal temperature water quality standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

U.S. Fish and Wildlife Service. 2008. Birds of Conservation Concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp. [Online version available at <http://www.fws.gov/migratorybirds/>]

Utz, R., R.H. Hilderbrand, and D.M. Boward. 2009. Identifying regional differences in threshold responses of aquatic invertebrates to land cover gradients. Ecological Indicators 9:556–567.

Van Sickle, J., and S. V. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. Canadian Journal of Forest Research 20: 1593-1601.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of. Fisheries and Aquatic Sciences 37: 130-137.

Verstraeten, G, J. Poesen, K. Gillijns, G. Govers. 2006. The use of riparian vegetated filter strips to reduce river sediment loads: an overestimated control measure? Hydrol Process 20(20):4259-67.

Wahl, T. R., B. Tweit, S. Mlodinow, editors. 2005. Birds of Washington: status and distribution. Oregon State University Press, Corvalis, OR.

Walsh C.J., K.A. Waller, J. Gehling and R. MacNally. 2007. Riverine invertebrate assemblages are degraded more by catchment urbanization than by riparian deforestation. Freshwater Biology 52: 574–587.

Walsh, C.J. and J. Kunapo. 2009. The importance of upland flow paths in determining urban effects on stream ecosystems. Journal of the North American Benthological Society 28(4):977-990.

Washington Department of Fish and Wildlife (WDFW). 1997. Washington State Status Report for the Gray Whale. _______. 1999. Washington State Recovery Plan for the Western Pond Turtle.

_______. 2009. Landscape Planning for Washington's Wildlife- A Priority Species and Habitat Guidance Document.

_______. 2012. Endangered Species 2012 Annual Report.

_______. Electronic reference. Comprehensive Wildlife Conservation Strategy. http://wdfw.wa.gov/conservation/cwcs/cwcs.html [Accessed December 26, 2013].

Washington State Conservation Commission (WSCC). 2000. Habitat Limiting Factors: Water Resource Inventory Area (WRIA) 6 Island County.

Washington State Department of Ecology (Ecology). 2002. Evaluating Standards for Protecting Aquatic Life in Washington's Surface Water Quality Standards Temperature Criteria: Draft discussion paper and literature review.

_______. 2004. Results of a Screening Analysis for Pharmaceuticals in Wastewater Treatment Plant Effluents, Wells, and Creeks in the Sequim-Dungeness Area. Publication No. 04-03-051."

Washington State Department of Health (WDH). 2012 2011 Annual Report: Commercial and Recreational Shellfish Areas in Washington State.

_______. Electronic reference. http://ww4.doh.wa.gov/scripts/esrimap.dll?name=BIOVIEW&Left=587799&Bottom=337200&Right=1337201&Top=1360000&Co=Select+a+County&Beach=Select+a+Beach&Step=1&click.x=217&click.y=109. [Accessed October 28, 2013.

Washington State Department of Natural Resources (WDNR). 2010. Smith & Minor Islands Aquatic Reserve Management Plan.

_______. 2013. Washington Natural Heritage Information System List of Known Occurrences of Rare Plants in Washington July 2013 Island County.

Watson and Rodrick. 2000. Bald Eagle. 9-1 to 9-15 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Welsh, H.H., Jr and G.R. Hodgson. 2008. Amphibians as metrics of critical biological thresholds in forested headwater streams of the Pacific northwest, U.S.A. Freshwater Biology 53(7):1470-88.

Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia. Internet: http://outreach.ecology.uga.edu/toos/buffers/lit_review.pdfWigington, Jr., P.J., J.L. Ebersole, M.E. Colvin, et al. 2006. Coho salmon dependence on intermittent streams. Frontiers in Ecology and the Environment 10:513–18.

Wigington, P.J. Jr, S.M. Griffith, J.A. Field, J.E. Baham, W.R. Horwath Owen, J.H. Davis, S.C. Rain and J.J. Steiner. 2003. Nitrate removal effectiveness of a riparian buffer along a small, agricultural stream in Western Oregon. Journal of Environmental Quality 32:162-170.

Wilcox, J.D., J.M. Bahr, C.J. Hedman, J.D.C. Hemming, M.A.E. Barman, and K.R. Bradbury. 2009. Removal of Organic Wastewater Contaminants in Septic Systems Using Advanced Treatment Technologies. Journal of Environmental Quality 38 (1): 149–56.

Wilhere et al. 2013. George F. Wilhere, T. Quinn, D. Gombert, J. Jacobsen, and A. Weiss. 2013. A Coarse-scale assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin. Washington Department of Fish and Wildlife, Habitat Program. Olympia, Washington.

Williams, G. and R. Thom. 2001. Marine and Estuarine Shoreline Modification Issues. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation, by Battelle Marine Sciences Laboratory, Pacific Northwest National Laboratory, Sequim, Washington.

Willson, J.D. and M.E. Dorcas. 2003. Effects of habitat disturbance on stream salamanders: implications for buffer zones and watershed management. Conservation Biology 17:763-771.

Wipfli M.S., J.S. Richardson, and R.J. Naiman. 2007. Ecological linkages between headwaters and downstream ecosystems: Transport of organic matter, invertebrates, and wood down headwater channels. J Am Water Resour Assoc 43(1):72-85.

Wipfli, M.S. 2005. Trophic linkages between headwater forests and downstream fish habitats: implications for forest and fish management. Landscape and Urban Planning 72:205-213.

Wipfli, M.S. and D.P. Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology 47: 957-969.

Wondzell, S.M., J. Lanier, et al. 2009. Changes in hyporheic exchange flow following experimental wood removal in a small, low-gradient stream. Water Resources Research 45(5).

Wood-Smith, R. D. and J.M. Buffington. 1996. Multivariate geomorphic analysis of forest streams: implications for assessment of land use impacts on channel condition. Earth Surface Processes and Landforms 21: 377-393.

Wooster D.E. and S.J. DeBano. 2006. Effect of woody riparian patches in croplands on stream macroinvertebrates. Arch Hydrobiol 165(2):241-68.

Wyllie-Echeverria, S., T. Mumford, J. Gaydos, and S. Buffum. 2003. Zostera marina declines in San Juan County, WA Westcott Bay Taskforce Mini-Workshop, 26 July 2003.

Wynn, T. and S. Motsaghimi. 2006. The effects of vegetation and soil type on streambank erosion, southwestern Virginia, USA. Journal of the American Water Resources Association 42(1):69-82.

Yuan, Y.P., R.L. Bingner, and M.A. Locke. 2009. A Review of effectiveness of vegetative buffers on sediment trapping in agricultural areas. Ecohydrology 2(3):321-336.

Zedler, J.B., and S. Kercher. 2004. Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. Critical Reviews in Plant Sciences 23(5): 431–452.

Zhang, X., X. Liu, M. Zhang, and R.A. Dahlgren. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84.

Zhang, Y.X., J.S. Richardson, and X. Pinto. 2009. Catchment-scale effects of forestry practices on benthic invertebrate communities in Pacific coastal streams. Journal of Applied Ecology 46(6): 1292-1303.

APPENDIX A
OTHER SPECIES AND HABITATS OF POTENTIAL CONSERVATION CONCERN

Tables A1 and A2 identify species and habitats, respectively, that may be of conservation concern, but which are not explicitly protected under the County's existing regulations. These tables were generated through reference to WDFW's Priority Habitats and Species list for Island County (2013), WDFW's Comprehensive Wildlife Conservation Strategy (electronic reference), DNR's Natural Heritage Information System List of Known Occurrences of Rare Plants in Island County, Washington (2013), and The Nature Conservancy's Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment (Floberg et al. 2004). Many of these species are indirectly protected by the County's existing FWHCAs because their habitats are protected (e.g., aquatic species).

Under the County's existing FWHCA's, the following criteria must be met for a species to qualify as a Species of Local Importance:

1. Local populations which are in danger of extirpation based on existing trends (since January 1, 1985),
2. The species is sensitive to habitat manipulation, and
3. The species or habitat has commercial, game, or other special value, such as locally rare species.

Areas may be designated as Habitats of Local Importance if they meet the following criteria:

1. Documented use or high probability of use of the habitat by a species whose long term persistence is dependent upon conservation of the habitat or the habitat is proposed to be restored with the consent of the affected property owner so that it will be suitable for use by the species; and
2. Either high quality native habitat or habitat that has an excellent potential to recover to a high quality condition and which is either of limited availability or highly vulnerable to alteration.

3. Specific habitat features to be protected (for example, nest sites, breeding areas, nurseries, etc.).

Whidbey Audubon has provided the following information on species considered to be of local conservation concern:

Pigeon Guillemot

The pigeon guillemot is only the alcid species to nest in Island County. They depend on small bottomfish for feeding their young. They nest in burrows in bluffs, on a structure near the Keystone Jetty, and in rock crevices at Deception Pass. Whidbey Audubon Society has been studying the pigeon guillemot colonies around Whidbey Island for ten summers, beginning in 2004. They monitor 24 breeding colonies with the total number of adult birds averaging around 1,000, about 45% of which attempted to breed, occupying around 230 burrows, about 70% of which hatch chicks (Sarah Schmidt, personal communication, January 24, 2014). Observers have also documented prey selection which is primarily composed of gunnels and sculpin (Kind et al., 2010).

Northern Harrier

Whidbey Island has the largest breeding population of northern harriers in western Washington (J. Bettesworth, personal communication with Sarah Schmidt, 2014). Key nesting and hunting areas on Whidbey Island were identified during twelve years of nesting and productivity studies (Bettesworth 2014). “Historic and recent evidence suggests that the number of breeding harriers has declined across the species’ range” (Slater and Rock 2005). “Habitats have no formal protection and human development often eliminates prime hunting and nesting habitat and crop harvesting may destroy nests, eggs, and young. (Wahl et al. 2005)”

Black Oystercatcher

The black oystercatcher winters in significant numbers on the shores of Whidbey Island. This species is included in the US Fish and Wildlife 2008 list for Region 5, is a state monitored list, and “The Northern Pacific Coast Regional Shorebird Management Plan has identified the Black Oystercatcher as a regional species of high concern” (birdweb.org).

Olive-sided Flycatcher

The olive-sided flycatcher is a tropical migrant that shows up on numerous lists of bird species of conservation concern, including the US Fish and Wildlife

Service (2008, Region 5), Audubon/American Bird Conservancy yellow list, Audubon Washington species of immediate concern, and Partners in Flight conservation list. Its habitat is "open mature stands of conifers or forest stands with high perches in tall trees and snags along the edges of clearings. Closely aligned to the distribution of forested areas." Population trends generally appear to be declining (Wahl et al. 2005). This decline is especially evident in the areas of greatest abundance, including the Cascade Mountains (www.birdweb.org). "Forest harvest practices that retain snags and live trees (potential nest trees) help provide suitable habitat." (Birds of North America online).

Table A1. Species of potential conservation concern in Island County. * indicates species identified as species of greatest conservation need by WDFW (electronic reference).

Common name	**Scientific name**	**State Status**	**Federal Status**	**Reference**	**Habitat in Island County**
Fish					
White Sturgeon	Acipenser transmontanus			WDFW PHS	Marine/ Estuarine
Pacific Herring*	Clupea pallasii	Candidate	Species of Concern	WDFW PHS	Marine/ Estuarine
Longfin Smelt	*Spirinchus thaleichthys*			WDFW PHS	Marine
Surf smelt*	*Hypomesus pretiosus*			WDFW PHS	Marine/ Estuarine
Coastal Resident/ Searun Cutthroat	*Oncorhynchus clarki*		Species of Concern	WDFW PHS	Marine, Freshwater
Coho Salmon	*Oncorhynchus kisutch*		Species of Concern	WDFW PHS	Marine, Freshwater
Pink Salmon	*Oncorhynchus gorbuscha*			WDFW PHS	Marine/ Estuarine
Sockeye Salmon	*Oncorhynchus nerka*	Candidate		WDFW PHS	Marine
Pacific Cod	*Gadus macrocephalus*	Candidate	Species of Concern	WDFW PHS	Offshore marine
Pacific Hake	*Merluccius productus*	Candidate	Species of Concern	WDFW PHS	Offshore marine
Walleye Pollock	*Theragra chalcogramma*	Candidate	Species of Concern	WDFW PHS	Offshore marine
Black Rockfish*	*Sebastes melonops*	Candidate		WDFW PHS	Marine
Brown Rockfish	*Sebastes auriculatus*	Candidate	Species of Concern	WDFW PHS	Marine
Copper Rockfish*	*Sebastes caurinus*	Candidate	Species of Concern	WDFW PHS	Marine
Greenstriped Rockfish*	*Sebastes elongatus*	Candidate		WDFW PHS	Marine
Quillback Rockfish*	*Sebastes maliger*	Candidate	Species of Concern	WDFW PHS	Marine
Redstripe Rockfish*	*Sebastes proriger*	Candidate		WDFW PHS	Marine
Yellowtail Rockfish	*Sebastes flavidus*	Candidate		WDFW PHS	Marine
Lingcod	*Ophiodon elongatus*			WDFW PHS	Marine
Pacific Sand Lance*	*Ammodytes hexapterus*			WDFW PHS	Marine/ Estuarine
English Sole	*Parophrys vetulus*			WDFW PHS	Marine/ Estuarine
Rock Sole	*Lepidopsetta bilineata*			WDFW PHS	Marine/ Estuarine

Common name	Scientific name	State Status	Federal Status	Reference	Habitat in Island County
Amphibians					
Western Toad*	*Bufo boreas*	Candidate	Species of Concern	WDFW PHS	Prairies, forests
Birds					
Brandt's Cormorant	*Phalacrocorax penicillatus*	Candidate		WDFW PHS	Marine
Common Murre*	*Uria aalge*	Candidate		WDFW PHS	Marine
Tufted Puffin*	*Fratercula cirrhata*	Candidate	Species of Concern	WDFW PHS	Marine
Western Grebe*	*Aechmophorus occidentalis*	Candidate		WDFW PHS	Marine
Nonbreeding concentrations of: Loons, Grebes, Cormorants, Fulmar, Shearwaters, Storm-petrels, Alcids	*Gavia spp.*, Podicipedidae, *Phalacrocorax spp.*, *Fulmarus spp.*, Procellariidae, Hydrobatidae, Alcidae			WDFW PHS Whidbey Audubon Society	Marine, breeding and nesting pigeon guillemot at Keystone Jetty, Deception Pass.
Breeding concentrations of: Cormorants, Storm-petrels, Terns, Alcids	*Phalacrocorax spp.*, Hydrobatidae, Sternidae, *Alcidae spp.*			WDFW PHS	Marine, cliffs, pilings, islands,
Brant*	*Branta bernicla*			WDFW PHS	Estuaries, fallow fields
Cavity-nesting ducks: Wood Duck, Barrow's Goldeneye, Common Goldeneye, Bufflehead, Hooded Merganser	*Aix sponsa, Bucephala islandica, Bucephala clangula, Bucephala albeola, Lophodytes cucullatus*			WDFW PHS	Forests, structures, wetlands, Documented occurrences of Wood Duck and Hooded Merganser nesting at Earth Sanctuary available from Whidbey Audubon Society

Common name	Scientific name	State Status	Federal Status	Reference	Habitat in Island County
Nonbreeding concentrations of: Barrow's Goldeneye, Common Goldeneye, Bufflehead	*Bucephala islandica, Bucephala clangula, Bucephala albeola,*			WDFW PHS	Marine, marine shoreline
Harlequin Duck	*Histrionicus*			WDFW PHS	Marine, marine shoreline
Snow Goose	*Chen caerulescens*			WDFW PHS	Estuaries, fallow fields
Tundra Swan	*Cygnus columbianus*			WDFW PHS	Estuaries, lakes, ponds, fallow fields
Waterfowl Concentrations	Anatidae			WDFW PHS	Estuaries, lakes, ponds
W WA nonbreeding concentrations of: Plovers and Sandpipers	Charadriidae, Scolopacidae, Phalaropodidae			WDFW PHS	Shoreline, mudflats, marine
Black Oystercatcher	*Haematopus bachmani*		Species of Concern	Whidbey Audubon	Shorelines, mudflats, marine. Winters in significant numbers along the shorelines of Whibey Island
Band-tailed Pigeon	*Patagioenas fasciata*			WDFW PHS	Forests
Northern Harrier	*Circus cyaneus*		Species of Concern	Whidbey Audubon	Prairie grasslands, fields and marshes.
Vaux’s Swift*	*Chaetura vauxi*	Candidate		WDFW PHS	Forests
Olive-sided flycatcher			Species of Concern	Whidbey Audubon	Forests
Purple Martin*	*Progne subis*	Candidate		WDFW PHS	Forests, structures, pilings

Common name	Scientific name	State Status	Federal Status	Reference	Habitat in Island County
Mammals					
Dall's Porpoise	*Phocoenoides dalli*			WDFW PHS	Marine
Harbor Seal	*Phoca vitulina*			WDFW PHS	Marine
Pacific Harbor Porpoise*	*Phocoena*	Candidate		WDFW PHS	Marine
Roosting Concentrations of: Big-brown Bat, Myotis bats, Pallid Bat	*Eptesicus fuscus, Myotis spp., Antrozous pallidus*			WDFW PHS	Forests, structures
Townsend's Big-eared Bat*	*Corynorhinus townsendii*	Candidate	Species of Concern	WDFW PHS	Caves, cliffs, forests, buildings
Keen's Long-eared Bat (formerly Keen's Myotis)*	*Myotis keenii*	Candidate		WDFW PHS	Forests
Columbian Black-tailed Deer	*Odocoileus hemionus columbianus*			WDFW PHS	Shrubs and forests
Invertebrates					
Pinto (Northern) Abalone	*Haliotis kamtschatkana*	Candidate	Species of Concern	WDFW PHS	Marine subtidal
Geoduck	*Panopea generosa*			WDFW PHS	Marine intertidal, subtidal
Butter Clam	*Saxidomus gigantea*			WDFW PHS	Marine intertidal, subtidal
Native Littleneck Clam	*Leukoma staminea*			WDFW PHS	Marine intertidal, subtidal
Manila Clam	*Venerupis philippinarum*			WDFW PHS	Marine intertidal
Olympia Oyster	*Ostrea conchaphila*	Candidate		WDFW PHS	Marine intertidal
Pacific Oyster	*Crassostrea gigas*			WDFW PHS	Marine intertidal
Dungeness Crab	*Metacarcinus magister*			WDFW PHS	Marine subtidal

Common name	Scientific name	State Status	Federal Status	Reference	Habitat in Island County
Pandalid shrimp (Pandalidae)	*Pandalus spp.*			WDFW PHS	Marine subtidal
Sand-verbena Moth*	*Copablepharon fuscum*	Candidate		WDFW PHS	Host plant- yellow sand verbena in sandy coastal habitats
Red Urchin	*Strongylocentrotus franciscanus*			WDFW PHS	Marine intertidal
Plants					
Pink fawn-lily	*Erythronium revolutum*	Sensitive		DNR	Most recent sighting in the county is before 1977.
California buttercup	*Ranunculus californicus*	Threatened		DNR	Most recent sighting in the county is before 1977.
Scouler's catchfly	*Silene scouleri*	Sensitive		DNR	Most recent sighting in the county is before 1977.
Puget Balsamroot	*Balsamorhiza deltoidea*			DNR	Most recent sighting in the county is before 1977.
Smooth Hornwort	*Phaeoceros laevis*			DNR	Most recent sighting in the county is before 1977.
Tolmie's Goldenrod	*Solidago missouriensis var. tolmieana*			DNR	Most recent sighting in the county is before 1977.

Table A2. Habitats of potential conservation concern in Island County.

Habitat	Reference	Description
Biodiversity Areas & Corridors	WDFW PHS	Biodiversity areas have been identified through a landscape scale assessment, or are areas in urban growth areas containing habitat that mostly consists of native vegetation. Corridors are areas of relatively undisturbed and unbroken tracts of vegetation that connect fish and wildlife habitat conservation areas, priority habitats, areas identified as biologically diverse or valuable habitats within a city or UGA.
Herbaceous Balds	WDFW PHS	Variable-sized patches of grass and forb vegetation located on shallow soils over bedrock that commonly is fringed by forest or woodland.
Old-Growth/Mature Forest	WDFW PHS	Stands > 3 ha (7.5 acres) having at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) that are > 81 cm (32 in) dbh or > 200 years of age; and > 10 snags/ha (4 snags/acre) over 51 cm (20 in) diameter and 4.6 m (15 ft) tall; with numerous downed logs, including 10 logs/ha (4 logs/acre) that are > 61 cm (24 in) diameter and > 15 m (50 ft) long.
Oregon White Oak Woodlands	WDFW PHS	Stands of oak or oak/conifer associations where canopy coverage of the oak component of the stand is 25%; or where total canopy coverage of the stand is <25%, but oak accounts for at least 50% of the canopy coverage. In non-urbanized areas west of the Cascades, priority oak habitat consists of stands > 0.4 ha (1.0 ac) in size.
West Side Prairie	WDFW PHS	Herbaceous, non-forested (< 60% forest canopy cover) plant communities that can either take the form of a dry prairie where soils are well-drained or a wet prairie.
Riparian	WDFW PHS	The area adjacent to flowing or standing freshwater aquatic systems. Riparian habitat encompasses the area beginning at the ordinary high water mark and extends to that portion of the terrestrial landscape that is influenced by, or that directly influences, the aquatic ecosystem.
Caves	WDFW PHS	A naturally occurring cavity, recess, void, or system of interconnected passages (including associated dendritic tubes, cracks, and fissures) which occurs under the earth in soils, rock, ice, or other geological formations, and is large enough to contain a human.
Cliffs	WDFW PHS	Greater than 7.6 meters (25 feet) high and occurring below 1524 meters (5000 feet).
Snags and Logs	WDFW PHS	Priority snag and log habitat includes individual snags and/or logs, or groups of snags and/or logs of exceptional value to wildlife due to their scarcity or location in a particular landscape.
Talus	WDFW PHS	Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.
Deception Pass	Floberg et al. 2004	Cliffs, beaches, kelp beds, Douglas fir - western hemlock - western red cedar forests, wetlands, herbaceous balds and bluffs, sphagnum bogs.

Habitat	Reference	Description
Dugualla Bay	Floberg et al. 2004	Sphagnum bogs, pocket estuary, Douglas fir - western hemlock - western red cedar forests
Crescent Harbor Forest	Floberg et al. 2004	Douglas fir - western hemlock - western red cedar forests
Oak Harbor	Floberg et al. 2004	Pocket estuary, Douglas fir - western hemlock - western red cedar forests
Ebey's Landing	Floberg et al. 2004	Coastal spit, kelp beds, herbaceous balds and bluffs, intertidal salt marsh, prairie, Douglas fir - western hemlock - western red cedar forests
Rodena Beach	Floberg et al. 2004	Beach, kelp and seagrass beds, mud flats, saltmarsh, Douglas fir - western hemlock - western red cedar forests
Lake Hancock	Floberg et al. 2004	Sphagnum bogs and fens, intertidal salt marsh, Douglas fir - western hemlock - western red cedar forests
South Whidbey Forest	Floberg et al. 2004	Puget lowland headwaters, forested wetlands, Douglas fir - western hemlock - western red cedar forests
Holmes Harbor	Floberg et al. 2004	Seagrass beds, salt marsh, Douglas fir - western hemlock - western red cedar forests
Sandy Point	Floberg et al. 2004	Seagrass beds, Douglas fir - western hemlock - western red cedar forests
Camano Head	Floberg et al. 2004	Douglas fir - western hemlock - western red cedar forests
Mountain View Beach	Floberg et al. 2004	Nearshore, Douglas fir - western hemlock - western red cedar forests
Woodland Beach	Floberg et al. 2004	Kelp and seagrass beds, Douglas fir - western hemlock - western red cedar forests
Utsalady	Floberg et al. 2004	Kelp and seagrass beds, Douglas fir - western hemlock - western red cedar forests
Port Susan Bay	Floberg et al. 2004	Mud flat, seagrass beds, saltmarsh
Gedney Island	Floberg et al. 2004	Beach, seagrass beds